THE USE OF INVESTIGATIVE METHODS IN TEACHING AND LEARNING PRIMARY MATHEMATICS IN LEBOWA SCHOOLS: A CASE STUDY.

SUBMITTED TO

RHODES UNIVERSITY

IN FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF EDUCATION (MATHEMATICS).

BY

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"MODIFA"

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DEDICATION AND THANKS

This work is dedicated to the following:

1. To my late father, Khutsisi Modumane Johannes Sebela, who passed away in 1967 while I was still fifteen years old and doing standard 6 at Ga-Mampa Village, in the Thabamoopo District of the Northern Province.

2. To my mother, Mamogobadi Rebecca Sebela, who cared for me from childhood up to this moment. May God bless you, Mogaleadi'a Serokolo!

3. To my elder brother, Segwere Daniel Sebela, who was responsible for my junior secondary schooling in Pietersburg (Mahlakaneng Senior Secondary School).
   May God preserve you, Mmafsi!

4. To my wife Norah with whom I spend sleepless nights while reading and preparing this report.
   Thank You for your kind support, Norah!

5. To my children: Tiisetso, Mogau and Emmanuel, who needed my care while I was busy but failed to get my best parental support.

To everybody I say; THANK YOU!
YOU REALLY GAVE ME SUPPORT.

CONTENTS:

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ABSTRACT:

This is a report on research conducted in Lebowa (Northern Province) Primary Mathematics Project schools. In view of the high failure rate of matric students, the researcher believes that it is necessary that ways should be devised to improve mathematics understanding from the first level of schooling. A research study was made of constructivist and investigative teaching and learning methods as employed by teachers in a number of primary schools in the area. The researcher believes that investigative and constructivist teaching approaches produce better results than the traditional approach. He further believes that children learn better in a co-operative non-threatening classroom environment.

A pilot study was made with two experimental schools and two control schools. The schools were selected from both urban and rural areas. The experimental schools are operating under the PMP and the control schools are not. The experimental schools are also supported by expert teachers called key teachers. Many of these key teachers have attended courses at Leeds University, while others have been trained locally in the theory and practice of constructivist and investigative teaching and learning. Chapter 3 illustrates clearly what is done in the Project schools.

The methodology employed in the research included questionnaire responses from 174 teachers, written tests by four schools (350 pupils), and interviews with 55 people, including directors of education, inspectors, principals, teachers and parents. Observations in classes were also done. Another questionnaire was given to 484 pupils. The tests were written on two occasions: an initial test was written during November 1993, the second year of the PMP project, while a second test was written the following year. Data collected was analysed and

positive results obtained.

The results from the tests indicated that pupils in experimental schools where constructivist and investigative approaches are used, perform better than those from schools where the traditional approach is still used. They indicated that children in PMP schools develop a better understanding of mathematics. This would seem to indicate that the constructivist and investigative approach to teaching produces better results than the traditional approach(es). The reader will find graphs indicating the results and their analysis in Chapters 4 and 5.

It is recommended by the researcher that:

- Constructivist and investigative teaching and learning methods be introduced to all schools.
- The services of key teachers be supported by the Department.
- The Department should equip all schools with the necessary materials for proper teaching and learning, or providematerials for schools to make their own teaching aids.
- Teachers be involved with materials production where they are given guidance on how teaching aids can be made.
- The curriculum for primary school mathematics be revised and changed, especially in view of the fact that at present it does not cater for local needs. It was planned by whites and it caters mainly for those with an European cultural background.

ABBREVIATIONS

The abbreviations which have been used in the report are:

PMP - Primary Mathematics Project.

L.I.T.C. - Lebowa Inservice Training Centre.

ODA - Overseas Development Agency.

R - Researcher.

TIMS - Tlhabane Investigative Mathematics Scheme.

RUMEUS - Research Unit for Mathematics Education University of Stellenbosch.

NPI - National Productivity Institute.

RIEP - Research Institute for Education Planning, Faculty of Education at the University of Orange Free State.

INSET - Inservice Training.

CHAPTER 1:

THE STATING AND SETTING OF THE PROBLEM

1.1. The Problem

Mathematics is one of the subjects which is regarded by many as a prerequisite for any career. Because of its status every child must study this subject up to the Std 7 or Std 8 level. The methods used in teaching should equip the child with the skills to cope with any relevant numerical or mathematical situation outside the classroom. Our traditional way of teaching places the teacher in a pivotal position in teaching, with the underlying assumption that the child is an empty vessel. The methods of teaching are teacher-centred, with the teacher acting in a way which serves to 'fill up' the students' empty heads. A teacher stands in front of the pupils and directs them by talking and with chalk-board illustrations. Generally children are not encouraged to question the teacher. Their only participation is perhaps writing down what the teacher tells them to. Yet even after such 'expert' guidance by the teacher, children are failing. Mathematics performance and results in schools remain poor, while the skills acquired in the classroom do not seem readily transferable.

The theories of educationists like Haire et al. (1978) and Howe (1988) suggest that children learn better when they are actively engaged in learning mahematics. How 'active' should this engagement be? At the very best, it should involve pupils talking together about what they are trying to learn, the theory being that meaning is negotiated through discussion (Sebela: Unpublished dissertation 1989/90; Birmingham UK). Piaget (1970) and Skemp (1979) have spoken about a constructivist model for learning. They suggest that knowledge

is not transferred ready-made to children, but that children are active participants who construct their own meaning to form new ideas from their own understanding. Constructivists do not regard pupils as empty vessels but as individuals who have their own informal mathematical knowledge which needs to be built onto. Constructivist theories suggest that pupils are responsible for their own learning, and that it is the teachers's responsibility to guide them in a way which will allow them to maximise their learning capabilities.

South African Black Secondary schools' matric mathematics results are very poor indeed. (Refer to the appendix 1.1 A on page 131 for the matric results of all races from 1989 to 1994; Source: University of Orange Free State Research Institute). It also seems that many families have developed a negative attitude towards the subject and that they even hate and are afraid of it. Students are discouraged by their school experience from including mathematics as one of their courses at the university level. In our Universities few students are doing the sciences, partly - it seems - because mathematics is regarded as very difficult. This is cause for concern, and it requires immediate attention.

A project has been initiated in Lebowa (Northern Province) to address the problem. The underlying rationale of this project is the constructivist postulate that children learn mathematics from their own experiences, out of which they build meaning for themselves. They assemble their own knowledge which arises from a range of problem solving experiences, and through collaborating in discussion they make mathematical sense out of it (Ernest 1989, Lakatos 1976). What has become known as the investigative approach is being used to see whether it can alleviate the problem our teachers and pupils are experiencing.

1.2. The purpose of this study

The main purpose of this study is to investigate the effects of the investigative teaching method in mathematics teaching, and to see whether the results gained through the use of this approach are better than the results before the methods were introduced. A further purpose of this study is to find ways of helping parents, teachers, lecturers and pupils/students to develop a positive attitude towards mathematics. The pass rate in matric mathematics for schools in Lebowa as a region, between the years 1985 and 1990, are given in the Tables 1.2.1 and 1.2.2, below.

TABLE 1.2.1: LEBOWA PASS RATES: MATRIC RESULTS FROM 1985 TO 1988

1985	1986	1987	1988
39,4%	29,8%	18,5%	22,2%

(Source: Advisory Services, Lebowa Education Department)

TABLE 1.2.2: PASS RATES OF FOUR CIRCUITS IN LEBOWA DURING 1990

Mapulaneng	Mogodumo	Mahwelereng	Polokwane
10,5%	18,8%	10,8%	14,9%

(Source: Advisory Services, Lebowa Education Department)

These two tables clearly indicate that mathematics results have not only been poor - an average pass of 23,7% - but actually seem to be declining, especially in the specified circuits during 1990. This situation needs to be improved.

The results of this report will be made available to mathematics educators throughout the province in the hope that changes will be implemented.

1.3. Research hypotheses

1.3.1. Children who are taught through investigative teaching will develop a better understanding of the subject than those who are taught through the traditional method where they only listen and react to the teacher's instructions.

1.3.2. The attitudes of parents, teachers and lecturers in areas where the investigative approach is used will become more positive.

1.3.3. Teachers will be inspired to use group work to good effect in their lessons.

1.3.4. Teachers will encourage discussion and investigation as an integral part of their mathematics lessons.

Background Support:

1.3.5 OBSERVATIONS IN SCHOOLS

1.3.5.1 EARLY OBSERVATIONS BEFORE THE NEW APPROACH WAS USED:

1.3.5.1.1 **Teacher dominating**:

Before the (investigative teaching) method was implemented, teachers were used to story telling, the lecture method and the question and answer method. Children were not encouraged to share ideas or hold discussions. A teacher would stand in front of the class

and the children would usually copy out what was written by the teacher on the chalkboard. The method to be used by the children was directed by the teacher and then children had to see to it that they understood that procedure only. Clements and Battista (1990) make the point that with this method children are passively absorbing mathematics instruction and curricula invented by other people. Knowledge is not created or invented by the child, and understanding is therefore not developed. For example: in ordinary addition or subtraction sums, the following was to be the only procedure and was introduced by the teacher to be transcribed and imitated by all pupils:

H T U	H T U
5 6 4	8 7 5
+ 2 7 8	- 3 8 7
8 4 2	4 8 8

For multiplication:

```
  763
 X 58
 6104
38150
44254
```

This procedure was that of the 'Do as I tell you' type.

1.3.5.1.2 **Passive listening without any discussion being allowed**:

Children were expected to listen to the teacher all the time, so that the flow of thought and information was one way from the teacher to the child. This is against the

constructivist view which argues that pupils do not get mathematical knowledge from their teacher, but from their own explorations, thinking, and participating in discussions (Loughlin, 1992). The only contribution from children was when the child read something to the teacher. The teacher was used to instructing the children to follow his own example and to copy his examples from the chalkboard. Generally questions from the children were not encouraged. The teacher was regarded as the only source of information.

1.3.5.2 OBSERVATIONS MADE AFTER TEACHERS HAD STARTED USING INVESTIGATIVE TEACHING METHODS:

Children were allowed to discuss their thinking with others, and the teacher. Discussion with their colleagues forced them to verbalize their thoughts and to develop understanding through cognitive reorganization. Terwel and Herfs (1994) also argue that when children receive an explanation or offer an explanation, the learning process is enhanced. In classes children were allowed to sit in groups of four or five to enable them to collaborate easily. The teacher had to visit each group instead of standing in front of them and writing on the chalkboard.

During the observations in the experimental schools the researcher came across the following discussion from a group of children.

The problem was: 56 - 38 (i.e. 56 subtract 38).

The Discussion: Philip: the answer is 18.

John: How did you get the answer? Tell us.

Philip explaining to them: To make 40, I add 2

to 38, it becomes 40. 40 is short by 16 to

make 56. Therefore 16 and 2 equals 18.

An explanation from Sarah in the same group:

56 = 50 + 6 and 38 = 30 + 8; 50 subtract 30 = 20,

8 is more than 6 by 2, 20 take away 2 is 18, it

means the answer is 18.

The subject teacher for this group of children was moving from group to group in order to guide them where they encountered difficulties. Time was also given to the children to report back to the whole class on how he/she have got the answer. When doing this pupils were allowed to write on the chalkboard instead of the teacher.

From the observations it was found that when pupils are given a chance to share their solutions, each will show his own working, which looks different from that of others. A problem such as the following was answered by grade 3 class with different solutions:

A bag of mealie-meal costs R6,00; two cold drinks cost R2,00 each; a bag of sugar costs R5,00 and two fish cost R3,00. How much will Sibonkile's list cost?

Refilwe's answer:

R2 + R2 for the drinks is R4. R6 for the mealie-meal plus R4 is R10. The R10 with R5 for sugar is R15. 3 taken 2 times for fish is R6. R15 And R6 is R21 total. Therefore Sibonkile's list cost R21.

Petrus' story or answer:

2 drinks; R2 + R2 = R4
2 fish; R3 + R3 = R6
R4 + R6 = R10
Sugar; R5 + R10 = R15
Total cost; R6 + R15 = R21.

On a multiplication operation to be used:

A school is going on a trip. Each child is to pay R15,00. The teacher wanted to know how much will be collected from A group of eight (8) children.

Here are the solutions which were given by five children in a grade 4 (Std 2) class:

15 + 15 = 30 +
15 + 15 = 60 +
15 + 15 = 90 +
15 + 15 = 120.
Mpho

15 + 15 is 30
30 + 15 + 15 is 60
60 + 15 + 15 is 90
90 + 15 + 15 is 120.
Lesedi

I counted 8 children
Each child brings R15.
Two children bring R30.
R30 + R30 is R60 for 4 children.
Again, R30 + R30 is R60 for
4 more children.
R60 + R60 is R120 for 8 children.
Tumelo

15 + 15 = 30
30 + 30 = 60
60 + 60 = 120
Juel

2 children is R30,
another 2 children is R30,
again 2 children is R30,
I will count in R30;
30, 60, 90, 120.
R120 altogether.
Lazarus

Each child will explain his/her solution to the teacher step by step. Then each one's mistakes are corrected to suit his/her working or his/her own thinking.

An interesting solution which was seen from a child in Standard 5 (Grade 7) at one of the project schools follows below:

The problem was: 8 x 6 =

The child indicated the following procedure:

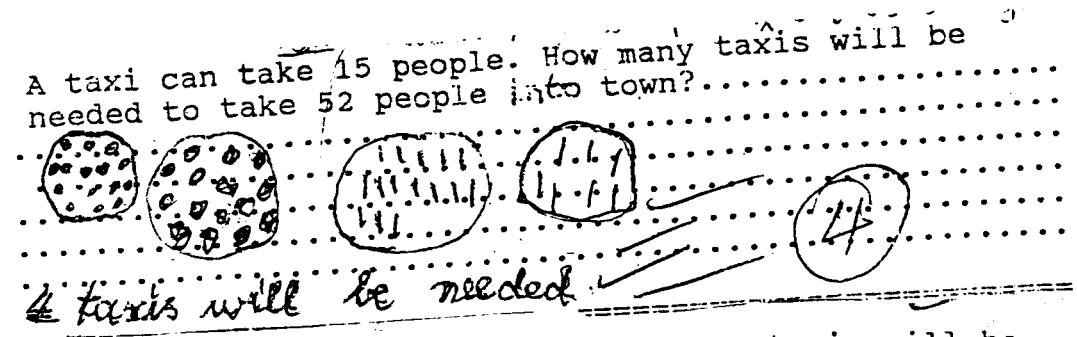
8 is short by 2 to make 10,
6 is short by 4 to make 10,
8 minus 4 is **4**, (diagonally from the first two statements).
6 minus 2 is **4**, (the same, diagonally as above).
4 multiplied by 2 is **8**.
The underlined 4 is common,
and it is 40;
So, the answer is 48.
Therefore 8 x 6 = 48.
Ramaesele

Here is another interesting question on taxis, given to a Grade (Std) 4 class:

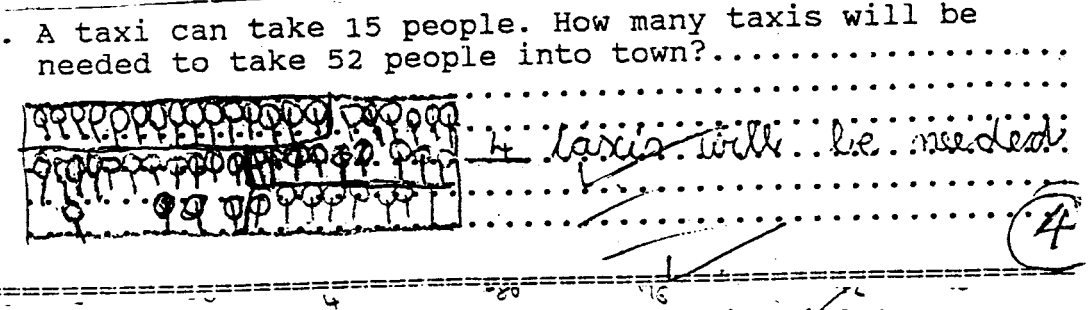
A taxi can take 15 people. How many taxis will be needed to take 52 people into town?

Three different solutions for Mankono, Lebogang and Mmabatho, all Grade 4 pupils, were discovered as follows:

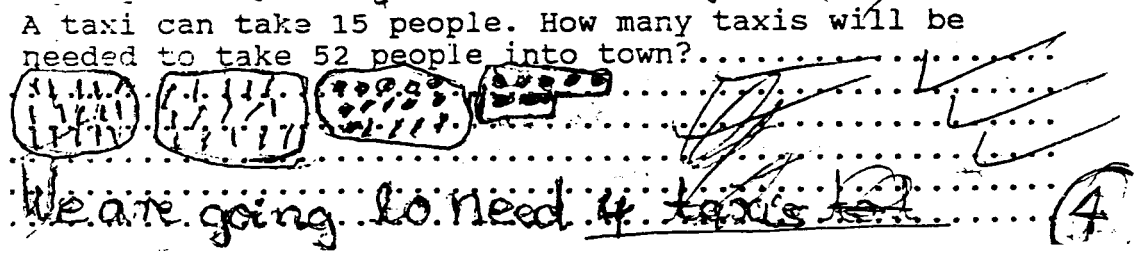
Mankono:



Lebogang:



Mmabatho:



As the learning was taking place in the classroom, the researcher could see that the classroom environment had shifted away from being merely the setting for a collection of individuals, to being a classroom of mathematical communities; it had also shifted towards the "domain of logic and mathematical evidence as verification" (Corwin, 1993:338), a domain in which pupils develop their insight into mathematical situations and their own ideas (Tonkin, 1995). They are not only memorising the teacher's ideas and methods. They are free to talk, to share, to interact and to play with the equipment given. In this way they also practise the leadership, communicatio, decision-making, trust-building and conflict resolution skills required for adult life (Johnson DW an Johnson RT, 1992).

1.4. Research method

The methodology used in this research embraces several procedures. Questionnaires, observations, interviews and test writing were all used to collect data. These methods were used in both the experimental and control schools. Details of what happened are outlined in Chapter 4 of this report.

1.5. Delimitation of the study

The study focussed on the teaching of mathematics in Lebowa (Northern Province) primary schools. Eleven centres with ten schools each were identified for the PMP project. An investigative teaching approach is used in these project schools. Two participating schools were used for pilot assessment and test trialling, and the results were analysed. The two are referred to as experimental schools in the study. Two other schools were selected from those not involved in the PMP project and are categorised as control schools. The control schools and experimental schools were used in piloting through comparison of their tests results. Observations, interviews and questionnaires were administered and trialled in the experimental schools and control schools.

The population consulted for interviews, observation and questionnaire included directors of education, inspectors, mathematics advisers, principals, teachers and parents.

CHAPTER 2:

REVIEW OF LITERATURE:

In this chapter literature on constructivist theory, co-operative learning and investigative teaching will be reviewed.

2.1. Researched ideas:

2.1.1. RELEVANT EUROPEAN FINDINGS

BRITAIN

Suggate (1995) states that adults and children invent their own informal procedures for calculation and that they rarely use the standard written methods outside of school. It is also stated that adults' performance in practical situations when buying in a supermarket reached a very high level of accuracy whereas the same group of people doing similar calculations in a written test, such as those used in school, score below average (Suggate, 1995). This is because outside school they are using informal methods. These methods, as understood from the same research, are more flexible and can be adapted more easily to a particular problem. Suggate (1995) further states that in schools considerable time is spent on teaching children standard algorithms for the addition and subtraction of multi-digit numbers, although these methods are never well understood by the children. She suggests that children should be helped to develop a sound understanding of the number system together with a range of robust mental methods of calculation, rather than be drilled by their teachers on the standard written algorithms. Ways of doing this include encouraging children to discuss their different ways of doing

calculations with each other, in groups and with the teacher. Discussion with the teacher will help the latter to listen carefully to what the children say, which in turn will show the children that their contributions are valued and enhance their confidence in their own ability to solve mathematical problems. The teacher can also identify both the strengths and limitations of children's understanding, and suggest improvements or help to overcome the difficulties.

NORWAY:

Research carried out in Norway by Hoines (1974) suggests that children need to be tested through interviews so that a full picture of the child's knowledge can be discovered during the lesson presentation process. This means that we should also resort to this type of testing throughout our teaching for the purpose of ensuring that information and knowledge are a form of two-way traffic. Interviewing children could be used as one of the methods of teaching and learning.

2.1.2. RELEVANT SOUTH AFRICAN RESEARCH FINDINGS

Discoveries have been made in South Africa following recent research into learning theories. Concerning those theories Du Toit (1991) suggests that:

- Each person has his/her own unique learning style and that no single teaching strategy for presenting a particular topic will suit everyone.
- Adults utilise informal, personal strategies to cope with everyday mathematics situations, even though they have been taught quicker and safer strategies in schools (Cockcroft, 1982).

- The best way for children to achieve numeracy is by counting, by being exposed to numbers, by using calculators and by handling situations in which they have to make use of and extend their existing knowledge of numbers (Du Toit, 1991).

TIMS PROJECT (NORTH-WEST):

Research on investigative teaching was done in Tlhabane in the North-West Province by Nick James and Monica Tumagole (a principal of one primary school) in 1993. They were very pleased with the results, which suggested that children taught using investigative teaching methods were comfortably in the success zone whilst the substantial majority of the control group of pupils taught using traditional methods were already failing mathematics in standard 2 (grade 4) (Tumagole & James 1994). See Appendix 2.1 B on page 133.

JUNIOR PRIMARY MATHEMATICS PROJECT (CAPE EDUCATION):

The project was undertaken by the Cape Education Department and RUMEUS. Murray's (1989) analysis of pupils' written exercises indicated the following:

- That computation methods for the same problem vary from pupil to pupil, depending on the level of mathematical thinking of which each pupil is capable at that time.
- That the same pupil chooses different computational methods for different problems, frequently being influenced by the characteristics of the numbers involved.
- That pupils are required to set out their reasoning processes systematically, and are regularly asked to explain their reasoning. This enables the teacher to gauge each pupils's

level of understanding exactly, insures against copying either answers or methods blindly.

- That pupils are unanimously enthusiastic about the freedom to choose their own methods.
- That pupils find that setting out their reasoning step by step enable them to discover their own errors. Their attitude towards errors also seems to have changed. (Refer to Appendix 2 C on page 140).

KHULISA REPORT:

Khulisa Management Services is an independent educational research unit which carried out research on PMP throughout South Africa during 1994. All the regions using PMP were visited for collecting data. This report was later produced by NPI in May 1995. The report clearly evaluated the quantitative and qualitative impact, sustainability, and cost-effectiveness of the PMP programme in South Africa (Khulisa Report, NPI: 1995).

The findings and recommendations as stated in the report are as follows:

i) In terms of quantitative impact, PMP appears to be making a strong contribution to more innovative and participatory learning methodologies. Teachers who participate in the programme appear to be enthusiastic and effective at encouraging more self-directed learning among pupils.

ii) The mathematics materials which are used appear to be relevant to the effective implementation of PMP methodology in that the methods used require that the children need plenty of materials. These help throughout their learning process.

iii) The introduction of the programme at the youngest age group levels appears to enhance overall mathematics performance by pupils. (Khulisa: 1995).

iv) PMP should be introduced at the Sub-Std A or Sub-Std B level to allow younger children to grow up with the methodology.

v) The government or PMP should make means for the provision of more teaching aids for mathematics.

vi) The availability of classroom support for teachers needs to be increased, and the quality also to be improved.

A SOCIO-CONSTRUCTIVIST APPROACH TO NUMERACY FOR CHILDREN AND ADULTS: OVERVIEW OF THE BASIC PRINCIPLES AND CURRENT STATE OF DEVELOPMENT IN SOUTH AFRICA (A paper by Human PG - HSRC supported) from Stellenbosch University, delivered in Pretoria, September 1990).

The following are the current suggestions from the research unit for Mathematics Education at the University of Stellenbosch:

i) In the constructivist approach learners are led to view all methods of computation as alternatives and nor as prescriptions, and they are allowed to exercise independent individual choices of methods.

ii) In the socio-constructivist didactic contract the instructor/teacher has a facilitative, consultative and managerial role, but refrains from direct teaching. Instead, the teacher/instructor poses a variety of realistic problems which induce learners to construct the concepts of addition, subtraction, multiplication and division and also the methods for executing these operations.

The learners have to understand that they have to solve the problems and construct their methods of computation independently, that they should also be able to explain their methods clearly and logically in writing and verbally, to share the solutions with their

peers, and even to adapt methods from their peers.

iii) Young children and adults reveal a wealth of natural (intuitive) computational strategies, provided they possess an adequate analytical understanding of numbers. This analytical understanding of numbers comprises at least the ability to interpret numbers in terms of their decompositions which formulate the basis of the number-naming system, e.g. seventy-three is "seventy and three", by symbols $73 = 70 + 3$.

iv) It is stated that methods of computation are viewed as authoritative prescriptions, and children naturally seek information on whether the prescriptions are from the teacher/instructor as the perceived authority, and tend to refrain from learning through independent attempts to solve numerical problems or to execute computational tasks. In computational mathematical problems children can obtain information on how to solve such problems from their own creative personal constructions and by sharing with their peers.

v) In the constructivist approach, the learners' concepts of the basic operations are allowed to develop more gradually from the experience of solving a variety of realistic numerical problems which serve as the starting points and context for the construction of computational methods.

vi) The rate of learning progress in the constructivist approach is substantially higher than that experienced with the traditional approach - in terms of the magnitude on numbers that can be handled, the variety of problem types that can be solved, and the communication skills about numbers and methods of computation that are attained.

The major findings from their research was that the major advantages of the socio-constructivist approach to basic numeracy are probably the base it provides for further learning of mathematics, both in terms of computation and the positive self-reliant attitude towards learning mathematics. For example they say that pupils who had a one year experience of the constructivist approach in Standard 2 are doing more advanced work in the first year of their higher primary standards.

2.2 Constructivist theory, co-operative learning and investigative teaching; what are these?

2.2.1 Constructivist Theory:

Traditionally mathematics instruction is based on a transmission and absorption model where pupils absorb the mathematical structures invented by others. Teaching consists of the transmission of sets of established facts, skills, and concepts to students (Clements & Battista, 1990). Children are expected to listen to the teacher throughout the day without talking or asking questions.

This is a behaviourist approach to learning which assumes that learning comes through a process of repetition and reinforcement. This means that the teacher has to say what she wants the learner to know. The behaviourist expectation is that, by repeating what the teacher has said, many times, the child will internalise the message (Laridon, 1994). When the child fails to remember the message, the teacher can opt to use some reinforcing strategies to get the message through. Corporal punishment is sometimes used for reinforcement!

The social constructivist approach is fundamentally different from that of the behaviourist.

- The social constructivist does not accept that children learn by rote but that learning is internal to the learners, i.e. the child has to construct his/her own meaning from what is to be learned. Learning entails the acceptance of multiple interpretations of the same situation by different individuals. This means that the constructivist has discarded the view that there is only one correct method.
- The social constructivist believes that knowledge is socially constructed. This requires the constructivist to create a climate in the classroom where children can learn more freely in a social way. In the constructivist classroom children learn by interacting with concrete material, sharing ideas and discussing subject matter with the learner and each other. The teacher also provokes discussion among his/her students by asking questions that will lead them to discuss and build their own interpretations. Through this method the children are encouraged to learn from each other and to accept that gaining knowledge is inseparable from making errors.

The social constructivist approach differs from that of the radical constructivist, because radical constructivism believes that, as a product of human inventiveness and human activity, mathematics is changing continuously. This means that mathematics is constructed as a way of thinking rather than as a body of fixed knowledge or content. The manner in which schemas are organised and reorganised in the mind are private to the individual.

- The constructivist teacher prepares a classroom environment where children can voice their opinion without fear. That is, an opinion once expresses is regarded as only one of

several approaches to a possible solution. Each idea is debated by the class on its merits, and the one which they think will fit the situation they are discussing best is agreed upon by consensus.

CONSTRUCTIVIST METHODS IN THE CLASSROOM

As discussed earlier, constructivists hold that we can only understand objects of which we can build mental schemas. In primary schools a lot of material is needed because pupils learn mainly by reflective interaction with those materials and with each other. The following are some guide-lines on what to do:

- Allow the learners to build their own mental pictures of things or objects by letting them manipulate and talk freely about the objects with their peers.
- Do not preach or dictate to the children about what you want them to know. They should build their own knowledge by experimenting. This will be remembered easily without unnecessary recourse to rote learning.
- Your role as a teacher should change from that of teller or authority of all the knowledge children should know or should not know. Respect the knowledge children bring with them into the classroom. You should be the one who encourages children to tell you (or their colleagues, and the teacher as co-partner) about their own knowledge or experiences.
- Teach your pupils to listen considerately to one another. They must not laugh at the unusual thoughts of others; instead they should discuss such ideas and compare them with their own ideas.
- Children can interact with each other most effectively when they are seated in groups. But remember, it is of no use if the children are seated in groups, but do not interact with one

another, e.g. if they sit facing the front of the classroom listening to the teachers all day long.

- Use a problem-centred approach to teaching. Base your teaching on tasks or problems children can relate to. This will give your children the opportunity to construct their own mathematical knowledge and understanding.
- As a supervisor, you cannot make your children learn constructively without changing yourself. If you have difficulties with some sections talk to your colleagues (in your schools or in neighbouring/other schools). Share your problems and ideas with them.
- Have workshops with your colleagues in the afternoons during spare time where you also share ideas. Consult newspaper or magazine articles with your colleagues. That will give you ideas of what other teachers in other parts of the country and the world are doing.
- Children create new mathematical knowledge by reflecting on their physical and mental actions. What children learn or acquire is made meaningful by integrating that into their existing structures of knowledge.
- Learning is a social process in which children grow into the intellectual life of those who are around them (Bruner, 1996). A mathematics classroom should be seen as having a culture where children are involved in negotiations, explanation, evaluation and the sharing of ideas.
- As Olivier (1989) has indicated, students are not to be seen as passive receivers of knowledge.

Students learning through constructivist approaches are seen to be autonomous and self-motivated, and they in turn acquire the understanding that they do not acquire mathematics knowledge from their teacher but from their own explorations, thinking and participation in discussion. The role of the constructivist teacher is to guide and support the student's

invention of viable mathematical ideas rather than to transmit "the correct" adult ways of doing mathematics (Clements and Battista, 1990:35). Teachers using this method must be able to provide tasks and opportunities for dialogue that bring about appropriate conceptual reorganizations in the pupils. Mason (1989) emphasises the same idea by indicating that pupils make sense of the world by assembling fragments of their experiences into some sort of story. This is again stressed by Gadanidis (1994:93):

> ... students acquire new knowledge through an active process of assimilation and accommodation, where new as well as existing knowledge is transformed as students construct more inclusive schemas of understanding. This theory contrasts the view that students acquire new knowledge through a passive process of transmission, where knowledge is passed unchanged from teacher to student. Even in learning situations that are considered passive, such as a lecture, students construct their own understanding. In a constructivist view of mathematics learning, the question is not whether students construct understanding of mathematical concepts but rather how good are their constructions. Thus, a constructivist teacher's emphasis is on creating learning environments that help students create good schemas of mathematics understanding.

In this approach pupils are encouraged to exchange points of view rather than accept an imposed idea of correct and incorrect methods. They are seen essentially as scientists who constantly test out hypotheses about the world in which they are living as social beings (Piaget, 1970).

Sehlare (1993: 185-190) has argued that the following benefits are gained from a constructivist approach:

- individuals may feel free to participate. In this way, they improve their ability in both verbal communications and discussions;
- they develop in several qualities: confidence, perceptions, and ability to listen. They could also

enhance their interest and attitude towards the subject.

Ernest (1989) emphasises the need for discussion by pointing out that language and forms of life are shared by individuals. This suggests that the teaching of young children could build through conversation on the experience and perceptions that they share. (i.e. young children's learning could be build through conversation).

2.2.2. Co-operative learning:

An important aspect of reconstructing education in South Africa is the transformation of classroom practices to include approaches to learning and teaching which are "learner-centred and non-authoritarian and encourage the active participation of students in the learning process" (ANC, 1994:69). At present group work is beginning to appear in our classes. From the constructivist point of view group work and co-operative learning are essential.

Co-operative learning is thought to work well in mathematics because it pulls pupils of differing abilities together. Pupils of different background are placed in situations where they can all participate equally in learning. In his discussion of peer group co-operative learning, Brodie (1995) suggested that peer groups tend to provide more equality in interaction and to allow pupils more control over the learning situation and the knowledge developed. A report by Lilford (1995:124) supports co-operative learning by quoting from the Bible: "two are better than one, because they have a good reward for their toils. For if they fall, one will lift up his fellow, but woe to him who is alone when he falls and has not another to lift him up." Lilford (1995:126) quotes a Std 9 girl, Jennifer Hole, who says: "Working together and having the chance to give your opinion boosts your confidence and

encourages you to work even harder. My marks went up by five percent."

Sutton and Oberholtzer (1992) has suggested that co-operative learning has five essential elements:

- positive interdependence,
- face-to-face interaction,
- individual accountability,
- interpersonal social skills,
- analysis of how the groups work.

In groups, pupils are dependent on one another. The interaction is a verbal exchange among them. They are themselves responsible for learning to use the material. Children learn to work together with other people just as they need to be in life as a whole. They are also developing their social responsibility. Davidson and Maher et. al. (1990) has argued further that small groups provide a social support mechanism for the learning of mathematics, while Brombacher (1995) states that the notion of co-operative learning comprises more than just group work. This is understood to mean that group work is where individuals are working with a particular person dominating, i.e. where only one member is accountable and the rest are depending on him/her, while co-operative learning means that all group members are accountable and they reach agreement through mutual argument and consensus while learning from one another. In co-operative learning each member is used as a resource. It also recognises that pupils have no innate skills to work together, and seeks to use the time in class for the inculcation of life skills for working together.

2.2.3 Investigative teaching in mathematics classrooms:

Constructivists make a central assumption that constructivist learning and investigative teaching allows children to build mathematical knowledge through understanding via active participation in lessons. Barbara Jaworski (Ernest, 1989) states that investigative approaches to teaching and learning involve providing opportunities for pupils to ask their own questions and follow their own lines of inquiry. Loughlin (1992) indicates that knowledge construction depends on interaction between the subjectivity of learners and the implicit and explicit power of the pedagogic situation; and all students possess multiple frames of reference with which to construct knowledge by virtue of their ethnic background, race, class, gender, language usage, religious, cultural, and political identities, as well as such characteristics as their sexual orientation and physical appearance.

The method requires the teacher to have confidence in him/herself and be flexible in his/her approach. Pupils are given the freedom to interrupt the teacher when they do not understand, so that further clarification can be done before a lot of misunderstanding develops.

This approach discourages teachers from being simple imparters of knowledge (Lerman, 1983). Instead they become the facilitators of the pupils' activities, so as to allow learners to construct meaningful mathematical knowledge for themselves (Ernest 1989, Lakatos 1976). The approach opens room for back stage participation which allows children to talk and debate: the teacher stands aside and becomes the observer of what the children are doing; children are more actively involved than the teacher, whose role is nevertheless to

facilitate the participation within the groups. Tonkin (1995) supports the idea that discussion between pupils is essential in the learning of mathematics, and suggest that investigations provide ideal opportunities to promote group work and interaction between pupils. Through group work children learn to work collaborately and cooperatively.

James (1992) proposes the following model of investigative teaching, which he calls the "Do, Talk and Record Model." (See figure 2.4 on page 31).

i) *Do and talk* - the learners do practical activities, and the teacher feeds in the necessary language to enable them to talk about what they are doing, encouraging them to explain it in their own words. By practical activities the researcher means tasks in which children are able to apply their senses - touch, sight, hearing and feeling - to the learning aids in their possession. Some activities might include playful games. The value of such participation is emphasised by Hoines (1987:57), who says:

> Many of us think aloud when faced with difficult problem. We talk or write while we are thinking because it helps us to find a solution.

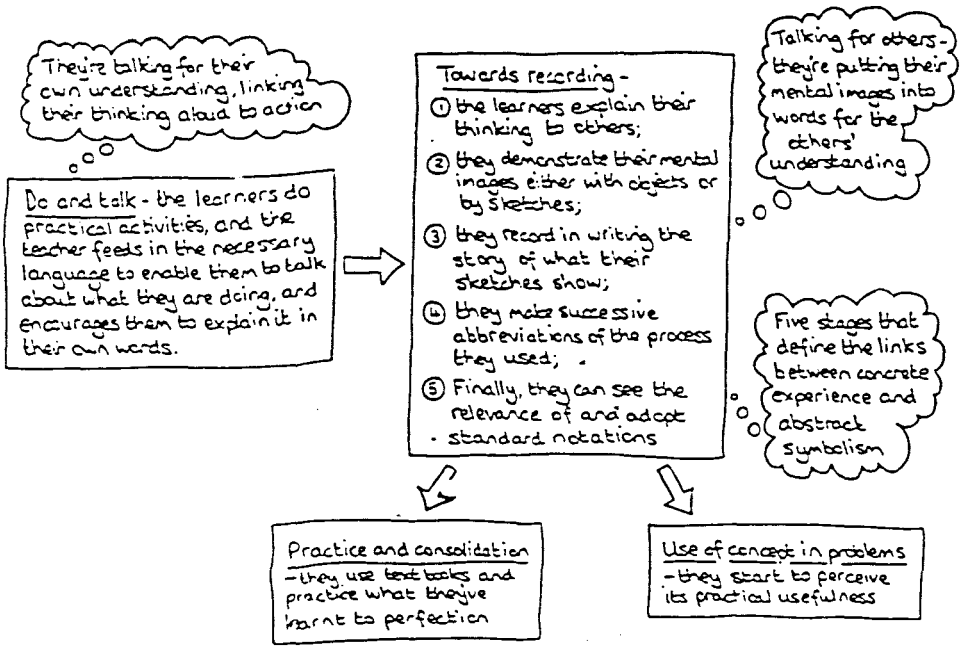
This clearly indicates the need to allow pupils to talk and to write down what they are talking about. This activity will improve their thinking skills.

ii) *Towards recording* (The five stages that defines the links between concrete experience and abstract symbolism) - the learners explain their thinking to others; they demonstrate their mental images either with objects or by sketches; they record in writing the 'story' that their sketches show; they make successive abbreviations of the process they have used; and finally, they see the relevance of and adopt standard notations.

iii) *Practice and consolidation* - they use textbooks and practise what they've learnt to perfection.

iv) *Spaced review* - they go back to use the principles they've learnt after a period of time

Figure 2.4.



SOURCE : Nick James in Moodley, Njisane and Presmeg (edds) 1992; Mathematics Education for In-Service and Pre-Service Teachers. Shuter and Shooter, PIETERMARITZBURG.

has elapsed.

v) *Use of concepts in problems* - they start to perceive the practical usefulness of what they have learned.

James (1992) has summarised the thinking process which the teachers and children are engaged in as following this procedure:

Specialising - Building confidence - Seeing generality-

Expressing generality - and Checking and convincing.

(See figure 2.5 on page 33).

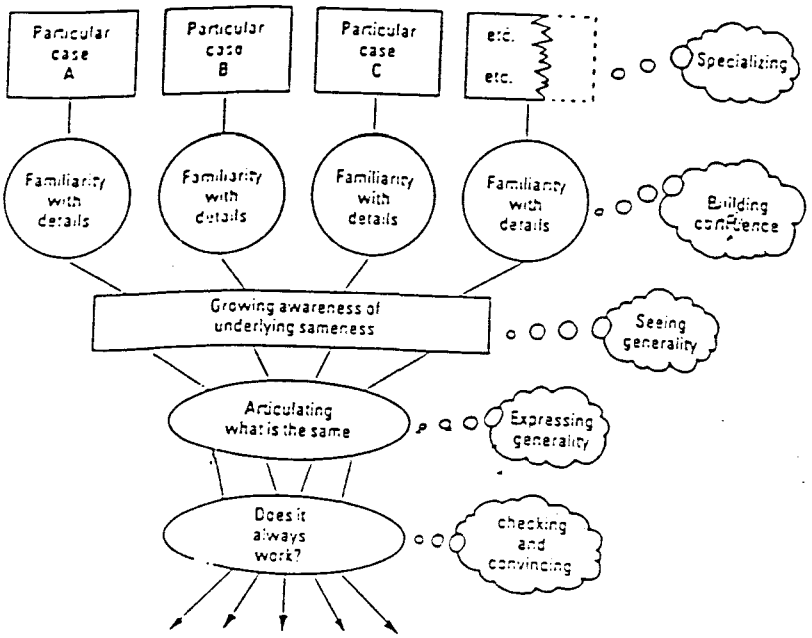
An investigative approach to teaching and learning as understood by the researcher involves providing opportunities for pupils to express and explore ideas for themselves. It requires the teacher to be willing to explore whatever comes up. It does not prevent the teacher from posing questions which alert pupils to ideas which the teacher considers to be important, but it does involve the teacher in being prepared for a wider consideration of ideas than an expository style might allow (Jaworski: in Pimm, 1988).

James's ideas accord with those of Polya (1945), who was the pioneer of investigative teaching. The steps recommended by Polya are:

- understanding the problem,
- devising a plan,
- carrying out the plan,
- and looking back.

In investigative teaching, meaning is negotiated through discussion. Educationist like Haire

Figure 2.5.



SOURCE: Nick James in Moodley, Njisane and Presmeg (eds) 1992; Mathematics Education for In-Service and Pre-Service Teachers. Shuter and Shooter, PIETERMARITZBURG

et al. (1978) and Howe (1988) stress that children learn better when they are engaged in talking about what they are trying to learn. The British Cockcroft Report (1982) also recommend that focussed discussion whilst doing investigative work be employed in mathematics teaching. A report of the American National Council of Teachers of Mathematics (1989) supports the view that discussion assists mathematical development, when it states:... communication plays an important role in helping children construct links between their informal, intuitive notions and the abstract language and symbolism of mathematics; it also plays a key role in helping children make important connections among physical, pictorial, graphic, symbolic, verbal and mental representations from mathematical ideas.

(NCTM 1989:26)

In conjunction with the notion that mathematical discussion helps in meaning building, it is emphasised that the study of mathematics should be done through problem solving in order to make mathematical concepts more relevant to the learner (Kamii, 1990). In this way, children learn to articulate their points of view ; they learn to listen to others, to ask appropriate questions, and to recognise and respond to mathematically relevant challenges; and in these ways, to develop their mathematical conceptions and their applications (Ernest, 1989).

2.2.3.1 Problem Solving:

With respect to problem solving, a basic tenet is that problems should be formulated in relation to things happening in the environment of the children (NCTM, 1989). Julie (1993) also insists that high priority should be given to the child's everyday experience of the real world. The child as a learner is able to formulate his own strategic knowledge through the experience and then to select the best strategies appropriate to the problem. In

problem solving the knowledge of concepts and algorithms alone is not sufficient (Stoker, 1991). The PMP project which is being run in Lebowa also tries to employ the strategies discussed.

Polya (1945) identified strategies for problem solving which he calls "heuristic" and which are used by most problem solvers.

The stages range from:

- Draw a diagram,
- Examine special cases,
- Introduce notations, to
- Noticing quantities that increase or decrease together.

The following are the main ingredients for problem solving according to Simmons (1993:125):

a problem,

some strategies,

enough knowledge to get started,

the necessary materials to work with,

time,

some facilities for monitoring the process.

Brandes and Ginnis (1986:71) also offer a list of strategies and steps for problem solving:

- Define the problem, work out whose problem it is
- Discuss all the ins and outs of it, gathering information

- Brainstorm for solutions
- Choose a solution to try
- After there has been time to try it, evaluate that solution
- Back to the drawing board, if necessary, or congratulate yourself on a problem well solved.

The problem-solving process should therefore follow the following sequence:

- Situation,
- Problem,
- Mathematical problem,
- Using mathematical knowledge, techniques and insight, and
- Solution. (Simmons, 1993)

Ball (1994) has mentioned that in problem solving the focus needs to be on explanation and the justification of the results and not merely on spotting relevant patterns. Like James (1992), he stresses the issue of doing and talking.

2.2.3.2. The role of the teacher in investigative teaching approaches (Constructivist and Co-operative learning):

The teacher is the most fundamental ingredient in the classroom (Cockcroft, 1982). The subject-matter for every lesson is introduced by him or her. In investigative teaching children are entitled to talk and discuss matters. The teacher who is not aware of this will feel embarrassed when children make a lot of noise (Sebela, unpublished B.Phil dissertation: 1989/91). The teacher should show confidence in the material being presented and to communicate in a clear, unhurried, and unambiguous manner to the class (Simmons, 1993). If it is necessary for the class to remain silent, the teacher is entitled to

oblige them to keep silent. However, lively but controllable noise for the discussion can be maintained.

The teacher should be able to encourage pupils' personal responses as well as introducing controversial matters to them (Howe, 1988). The controversial matters lead to debatable issues being questioned and analysed by the children. A similar idea that exploration of the incorrect answers can lead to useful discussion in different groups, is also emphasised by Cockcroft (1982).

Exposition by the teacher is of much importance to the introduction of a mathematical subject (Pirie and Schwarzenberger, 1988) and will stimulate interest and thinking. Thus the teacher has a big role to play in provoking mathematical discussion in investigative teaching. The teacher's role in investigative teaching and problem solving is emphasised by Miles (1970), Bridges (1979), Keltner (1974) and Howe (1988) as:

- encouraging personal responses,
- introducing controversy,
- summing-up and generalising,
- tolerating noise or silence,
- clarifying,
- informing and supporting,
- participating in different groups,
- developing security,
- orchestrating (i.e. letting them contribute) and
- valuing their responses.

These principles are supported and emphasised by Davidson and Maher et al. (1990: 55),

who has suggested that the functions of the teacher include the following;

> Initiating group work,
> Presenting guide-lines for small-group operations,
> Fostering group norms of co-operation and mutual helpfulness.
> Forming groups,
> Preparing and introducing new material,
> Interacting with small groups,
> Tying ideas together,
> Making assignments of homework or in-class work, and
> Evaluating student performance.

Thus most of the work is done by the pupils, with guidance from the teacher. Fostering co-operation between the pupils may necessitate training them to listen to others, and to build on someone else's ideas. Pupils should also be reminded to take turns in writing problem solutions on the board.

In conclusion, in a constructivist/investigative classroom the teacher has a facilitative, consultative and managerial role but refrains (as much as possible) from direct teaching. Instead he/she poses a variety of realistic problems which engage learners to construct the mathematical concepts. He/she must not be prescriptive but create learning opportunities to cater for different pupils' learning styles. A teacher must be conscious of the fact that pupils have a wealth of natural computational strategies, provided they possess an adequate background and analytical understanding of mathematical concepts (i.e. numbers, operation signs, etc.) Which he/she must provide (that's where investigative teaching comes in).

2.2.3.3. The pupils' role in socio-constructivist, problem solving and investigation:

Learners subjected to the social constructivist approach exhibit a high level of pride in their methods of computation and a positive self-concept with respect to numerical problem solving, and they tend to be strongly self-reliant when confronted with novel problems (Mabalane, 1994). All children are different. This means that their ways of working on a problem to arrive at a common solution will be different. Every child has the capability of understanding mathematics especially if his/her own methods are encouraged.

Children need the opportunity to participate in learning. For that reason Pimm (1988) has suggested that mathematics classroom events should ideally provide pupils with an opportunity for communication through all the major components of language use, namely: speaking, writing and reading. The development and enhancement of the pupil's understanding of the subject is brought about by the ability to communicate well in all the language modes about problems in mathematics.

Children need to be encouraged to agree and disagree amongst themselves rather than have right answers and correct methods imposed of them. In this way they are trained to think. In the logico-mathematical realm they will arrive at the truth if they debate long enough. For example if one child says that 5 + 3 = 8 and another one that 5 + 3 = 7, the teacher's role is to ask other children if they agree rather than to reinforce the right answer. To reach agreement children should discuss te matter in groups. Doise & Mugny (1984) did experiments on children in group work and discovered that children who are given a chance to agree, disagree or convince one another, demonstrated a higher level of thinking ability than children who are never given that chance to engage in discussion.

2.3. Concluding remarks on literature review:

The researcher has in this chapter discussed the major ideas concerning computational and investigative approaches gleaned from the relevant literature. These are significant for enhancing teaching and learning skills. The researcher's report which follows will explore some of the findings from his research in the Northern Province. The report will clearly indicate that the constructivist approach and co-operative learning are advantageous to our teaching and learning situation.

CHAPTER 3:

Mathematics teaching in Lebowa with particular regard to the PMP (PRIMARY MATHEMATICS PROJECT) and what it entails

3.1. INTRODUCTION:

In this chapter the history of mathematics teaching in primary schools in Lebowa will be discussed. The relevant background and the in-service training employed as from 1981 in the region, as well as the problems encountered, will also receive attention.

BACKGROUND INFORMATION ON PMP IN SOUTH AFRICA, AND HOW IT CAME TO LEBOWA

PMP (Primary Mathematics Project) is and independent educational trust established in 1993. It represents the accumulation of assistance from the ODA (Overseas Development Aid) and the British Council since 1981. In 1989 this assistance was developed into a three year project funded by the ODA at a total cost of over 1m rand. The project provided for programmes of in-country workshops, conferences and courses operating in seven regions of South Africa, viz: Eastern Cape (Port Elizabeth area), Eastern Cape (Grahamstown area), Gazankulu, Kwa Zulu, Lebowa, Qwaqwa and Western Cape. Between 1981 and 1990, more than 200 teachers were granted bursaries to attend three-month courses at Leeds University in England. In Lebowa, for example, there are more than forty teachers who attended such in-service training.

To formalise the impact over the last 10 years and to extend the work of the project, the regions involved have together agreed on the formation of a trust to control the activities of PMP. The trustees were selected by the existing PMP regions and the project was to be run by the National Steering Committee, comprising representatives from the existing PMP regions who would organise their own activities through Regional Steering Committees. Funding for the initial activities of PMP in South Africa had been obtained from the Independent Development Trust, and PMP is now set to consolidate and enhance its activities involving more teachers in an expanded programme.

PMP focuses on teacher development rather than directly on curricula matters or materials production. It seeks to improve the quality of teacher training, both at the pre- and in-service levels, through work with tutors in colleges of education and by strengthening INSET in the regions involved. Teachers are provided with support so that they can co-operate in a professional, self-sustaining way to raise the level of their professional activity. This professional activity includes seeking membership of associations, participating in local curriculum development, materials production and innovative teaching, and also in the INSET structures available in the various regions.

This research has been conducted in order to investigate and ascertain the influence of PMP strategies in the teaching and learning of mathematics in Lebowa Primary Schools. This object is pursued through an explanation of how and what is done throughout the region's project schools.

3.2. Short Historical Background

The Lebowa Education Department is in the fortunate position of having skilled mathematics practitioners. For more than fifteen years now, as from 1981, the British Overseas Development Aid (ODA), through the British Council, has offered a number of mathematics education officers and the key teachers in Lebowa three-months (or longer) scholarships to study mathematics education at Leeds and Birmingham Universities in the United Kingdom. Over 40 of these Primary Mathematics Project students, PMPs as we call them, have thus far been trained in investigative methods at a cost to the British community of well in excess of one million rand.

In the past the Lebowa Education Department (LED) has sought to capitalise on this resource of key teachers by running frequent one-week course to facilitate feedback from returning ex-PMPs on the outcome of their studies. At least one teacher per circuit plus one from each college of education were invited to attend these courses, which were usually run by the newly returned PMPs and several previous PMPs. We have however, come to doubt the efficiency of this method of organising feedback. The number of teachers being reached in the process, as well as the extent to which Investigative Approaches are being experienced and implemented, does not seem to be optimal.

Our thinking has turned to be establishing a network of locally-based agents-for-change in the hope that more qualitative, quantitative, and permanent results will be obtained. As explained at the beginning of this chapter, we have skilled practitioners to staff the network; to utilise their skills eleven centres have been identified, strategically sited around the former Lebowa homeland,from which to run a continuous program of in-service training for teachers

in those neighbourhood. Each of the eleven centres is surrounded by ten schools, from which all the mathematics teachers attend the workshops or the in-service courses. We call these skilled ex-Leeds practitioners Key Teachers. These Key Teachers have attended an in-service training course on Primary Mathematics Education, either at Leeds University or locally at Rhodes University through RUMEP, in which they have been exposed to the practical investigative teaching method for a three- of six-month period. With their expertise and experience they introduce the investigative and problem solving style of teaching to their colleagues.

The language of instruction policy at all primary schools in the region is mother tongue usage up to Standard 2 (Grade 4); but many of the schools in the PMP project have abandoned that policy. English is used as a medium of instruction with the support of mother tongue where there are problems.

Three types of key teachers have then been identified in the region as:

1. School-based Key Teacher:

Typically a principal or an ordinary assistant teacher. This teacher supports his `own school. He/she spends one week in each month running workshops with not more than fifteen teachers at a common venue. After the workshops, the teachers go back to their schools and try whatever they have learned. The key teacher then visits each of the schools or colleagues from her own school once within that particular month in order to provide support.

2. Teacher Advisory Key Teacher:

These people have a job specification that allows workshopping and classroom support on

a wide scale. Their role is to build teachers' expertise in teaching mathematics to the children. They run monthly workshops with 25 teachers or more from the ten schools they are working with. They also do classroom support, as well as taking care of other mathematics activities from primary schools up to the secondary schools.

3. College-based Key Teacher:

These are the lecturers from the colleges who also run workshops with their student teachers and in-service teachers from four to five primary schools under their care. They also visit those schools for classroom support purposes.

3.3 THE PROJECT ITSELF

3.3.1 The Multiplier Effect:

The plan is that each of the 30 key teachers will discipline two new key teachers each year. From this group newly confident teachers will emerge with the potential to become new key teachers or additional local agents-for-change. In this way, the network of local agents-for-change will expand from the original 30 ex-PMPs in the first year to about 60 key teachers in year 2; with a corresponding growth in curriculum development amongst the teachers in the whole of former Lebowa. Year 3 should see the number of key teachers and the number of teachers they influence grow still further as indicated in Table 3.2.1 (i) on page 46.

LOCAL AGENTS-FOR-CHANGE PER CENTRE X 11 CENTRES

EXISTING KEY TEACHERS	NEW KEY TEACHERS	IDENTIFIED NO. OF SCHOOLS INFLUENCED	NO. OF TEACHERS INFLUENCED	TOTAL NO. OF TEACHERS INFLUENCED
Year 1: 2	Nill	+/- 10	50	550
Year 2: 2	4	30	150	1 650
Year 3: 6	12	90	450	4 950

Table 3.2.1 (i)

From those statistics it is clear that after three years nearly five thousand (5 000) teachers should be influenced in using the approach in the whole region. Problems like transport and overcrowded classes which are clearly spelled out in section 3.5 of this chapter will hopefully be resolved by the new government.

3.3.2 The Role of the Key Teachers

3.3.2.1 In School-based Workshops:

Each key teacher holds monthly workshops at one of the five schools from 10:00 to 16:00, and rotates around the five schools. Twenty five teachers (minimally) attend each workshop and each teacher will receive two classroom support visits a month. The workshop is the forum in which content ideas for use in classroom are provided and in which teachers can personally experience what it is like to be when they are on the receiving end of investigative teaching approach. They are then encouraged to take those ideas and try them out in their classrooms, with support from the key teachers.

3.3.2.2 In Classroom-Based Support Visits:

Here the key teacher spends a whole day at a school and goes into the classroom of each of the five teachers he or she is working with. The class teachers begin by implementing what they understand the key teachers to have shown them about investigative methods during the previous school-based workshop. The key teacher, facing the problems the teacher faces, then makes suggestions about ways of improving the teacher's implementation of the approach. These can take the form of the following example from Nick James:

Let me show you what I would do in this situation right now.

If I stand right beside the child the interaction is between the

teacher and this child alone, the rest of the class switch off and fail to benefit; but I stand here on the opposite side of the classroom, the pupil speaks louder and everyone gets to hear how the problem was solved.

Listening to other people's ideas and learning from them is what the investigative method is all about.

3.3.2.3 In Termly Summits:

Three days/three nights regional conferences are held at different venues for all key teachers around Lebowa each semester. During 1992 and 1993 such summits were held at the Lebowa In-service Training Centre and Numbi Hotel in the Mpumalanga and Phalaborwa.

These summits have proved to be a vital means for team building and the professional development of the network of key teachers. Activities of a practical nature are workshopped by individual key teachers with the whole key teachers group. The summit provides a forum for reporting back their action-learning outcomes in the schools around their centres. As they share experiences, others are enriched and fuelled with ideas for the next term's workshops. The summits are also the place where we can fine-tune the key teachers' perceptions of investigative teaching; a means of constantly improving the quality of work being done in schools.

3.3.3 The Content of Workshops:

Workshops take the form of demonstrations and micro teaching, so that teachers will see good examples for the modifications to be made in their different schools. The same procedure is followed in the different centres by the key teachers when helping their neighbouring school teachers. Participating key teachers are divided into groups to discuss and to investigate. An example of a programme from one of the week-long workshops conducted for the new key teachers follows:

3.3.3 (i) Teacher as action learner and researcher.

3.3.3 (ii) Addition and subtraction in word problems - discussing strategies of solving and forming new mathematical concepts by investigations.

3.3.3 (iii) Model of investigative learning; that of

(a) Understanding the problem; (b) Specialising; (c) Building confidence; (d) Seeing generality; (e) Expressing generality; (f) Checking and convincing.

3.3.3 (iv) Investigating on how picture frames grow.

3.3.3 (v) Activities for use in "own workshops" on Counting, Number Cards, Number Squares (1 - 100 sheet), Number Bonds and Word Problems.

3.3.3 (vi) Reflection on the workshopping skills.

3.3.3 (vii) What the key teachers need to do back in their different colleges and schools.

3.3.3 (viii) New expectations of classroom behaviour as you change from "DO AS I TELL YOU" to "CAN YOU TELL ME HOW YOU DID IT?"

3.4. REFLECTIONS OF TEACHERS AND KEY TEACHERS DURING WORKSHOP COURSES

Participants were divided into groups. On each workshop day the workshops are run in such a way that the participants are able to discuss and reflect about the different lessons. They discuss the pros and cons of each lesson conducted by each key teacher. If the lesson was a practical demonstration on a class the same procedure is followed. The reflections or reviews are carried out in different groups.

The following are examples of reflections from groups A to E in one of the workshops (SUMMIT):

Group A:

1. Participation involved not only one group, for questions asked to or by one group could be extended to another group. e.g. group 1: How many bottle tops have you got? Group 2: How many bottle tops more do they need to make 10?

2. Children must be given a chance to express and formulate word problems from their environment using concrete objects.

3. Colours help to understand the concept "set"; it should be realised that colours should not interfere with addition of concrete objects.

4. Children should write what they say.

Group B:

1. Concerning the day's lessons nearly all the participants took part as compared to the previous day.

2. Key teachers have to be patient, so that they do not shout at the participating teachers when they make mistakes.

3. We realised that difficult terms like divisor, quotient, minuend, etc. were never used with sufficient emphasis.

Group C:

1. Participants learned from each other through active involvement and not necessarily from the lecturer conducting the lesson.

2. Answers given were not directed to the conductor but to the whole class.

3. The conductor gave the participants a chance to reflect on or review the lesson during his/her supervision and assistance.

4. The group suggested that anyone who is to give a report should be in a position where he/she is visible to all the participants.

Group D:

1. Talking and listening skills were catered for during the thinking process. Participants were encouraged to listen to responses randomly at different participants to repeat what

was said. Speakers had to direct their responses to the whole class.

2. Tolerance and patience were displayed by lecturers, so that all suggestions were accommodated.

Group E:

1. Aspects of the syllabus covered should be indicated at the end of each workshop; e.g. Addition, Subtraction and Word problems.

2. There are some participants dominating the discussion, i.e. those who are known by the lecturer. This can lead to boredom on the part of other members of the class.

3. The answers to the questions are usually telegraphic, e.g. How many green bottle tops do you have? One would say: 4. Participants should be encouraged to give answers in complete sentences, because this will help in developing language usage.

4. The group suggested that activities at workshops should include body movement so that participants do not get tired or fall asleep.

3.5. THE NATURE OF CLASSROOM SUPPORT

Project schools are visited by key teachers on a regular basis for support. The teacher to be supported teaches his/her class while observed. He/she is then assisted on the spot with

suggestions given by the key teacher. (Refer to section 3.2.2.2 for further information).

3.6. DIFFICULTIES AND PROBLEMS ENCOUNTERED IN RUNNING THE WORKSHOPS AND CLASSROOM SUPPORT

3.6.1. The main problem encountered is overcrowded classes. Schools have up to sixty of seventy pupils in one classroom. Most of our teachers find this situation difficult ot control, especially when it is time for them to be engaged in discussion.

3.6.2. In some places children are taught under trees and as a result they lose concentration, especially the little ones. In problem solving and investigation a lot of concentration is needed.

3.6.3. Most of our key teachers do not have cars. This makes it difficult for them to visit the other three or four schools for the purpose of classroom support, given that it needs to be done during school periods. Waiting for taxi during the day is not an easy task. In remote areas there are no taxis.

3.6.4. Teachers attending the workshops during the day left their children unattended. Between three and five teachers leave the school at the same time. Because classes cannot be left unattended, different teachers are attending workshops during the day. As such there is no continuity.

3.6.5. Teachers are used to conducting lessons according to their preparation plan. In

investigative teaching, the goals envisaged in their preparations are not always reached. Their complaint is that the syllabus is therefore not followed. Some principals have a negative attitude towards this approach as a result.

3.6.6. The key teachers' classrooms are unattended while they are on classroom support or Are workshopping in neighbouring schools. Principals are complaining about this problem.

3.6.7. Polarization exists between the PMP activities and the syllabus. The authorities and the teachers feel that PMP does not follow the syllabus.

3.6.8. Most of the teachers are not subject teachers; i.e. they also teach other subject and therefore they encounter problems because PMP seems to absorb all their attention. A lot of guidance is needed for the teachers to overcome this.

3.6.9. The project approach requires more time than the usual 30 minutes period.

3.7.10. In our schools, principals are used to giving new subjects to their teachers every year. The project needs teachers to get used to mathematics teaching and to gain experience in the use of the investigative teaching approach.

3.6.11. There is a shortage of advisors in subject advisory services, which means that not all circuits have got advisers.

3.7. CONCLUDING REMARKS

At the moment the PMP project is operating in selected schools in the Northern Province with a regional co-ordinator. The project is also employed in other schools throughout the whole country. The management of the project is done through the National Steering Committee and the National Co-Ordinator. The researcher hopes that the problems discovered in the province will be resolved by the national education ministry.

It is against this background that the research was carried out. The desire is that the methods recommended by the researcher be employed by all schools after being tried, investigated and tested in the experimental schools.

CHAPTER 4:

RESEARCH METHODOLOGY

4.1. INTRODUCTION:

This chapter describes how the present study was carried out. It offers an account of the questionnaire employed, the testing of pupils in the experimental and control schools, the observations and interviews which took place during the case study. The test was used for the purpose of evaluating whether investigative and constructivist approaches adopted in the PMP schools are improving the pupils' performance in mathematics. Can we confidently say that investigative teaching helps children to improve their mathematical understanding? Can we also say that children who take part in discussions are able to learn more efficiently than children who wait for the teacher to solve a problem for them? The overall purpose of this line of enquiry is to find a solution to the problem of the high failure rate in matric.

From the questionnaire and the interviews the researcher hoped to gain an understanding of the feelings of teachers and pupils with regard to mathematics teaching and learning. Interviews with teachers, principals and inspectors were conducted because they all form part of the teaching and learning situation. The other research technique used is sampling.

Sometimes when a school obtains poor results the teachers and principals are blamed without cognisance being taken of other possible contributing factors. This research therefore aims at establishing as full a picture of the situation as possible. If

investigative teaching methods are found to be good, then conditions conducive to their optimal implementation must be identified.

4.1.1. The educational research methodologies

In education we come across the following research methodologies, of which the researcher will give a short description on each:

- historical research,
- descriptive research,
- developmental research,
- ex post facto research,
- survey research,
- action research,
- triangulation research,
- correlation research
- and case study.

Historical research:

It is a process of supplementary to observations. Cohen and Manion (1989) defines it as a process by which historians attempts to test the truthfulness of the reports of observations made by others. In this type of research a mention is made about primary and secondary sources. Primary sources are those items that are original to the problem like weapons, buildings, coins, etc. Mason and Bramble (1989) stress that primary sources are those that are closest to the subject under study, such as eyewitness accounts and actual objects.

Secondary sources are things like books and encyclopedias. Mason and Bramble (1989)

again say that secondary sources are accounts offered by those who did not actually see the object or event but obtained information and provided descriptions of what they learned. In historical research data is usually not available for the researcher's direct scrutiny.

Descriptive research:

Descriptive research represent a broad range of activities that have in common the purpose of describing situations or phenomena. Such descriptions may be necessary for decision making or to support broader research objectives (Mason and Bramble, 1989). For example if the area office wants to plan implementing a new mathematics program, its members must have a knowledge of how many children will be in each of the grade levels to use the program for the next number of years. They are suppose to know the number of teachers who are not familiar with the new program. Research activities designed to meet these kinds of needs can facilitate decisions about the number of books and mathematics kits to be bought and the number of teachers to attend workshops on the use of the program materials.

Descriptive research can be divided into two categories, namely: *quantitative* and *qualitative* approaches. Quantitative descriptive research uses measurement and statistics (i.e."*it involves quantification of the phenomena under study*" (Mason & Bramble, 1989: 36). Quantitative research looks for more '*context - free*' generalizations (Wiersma, 1991).

Qualitative research embraces observations, impressions and interpretation of researchers. This type of research is '*context - specific*' with the researcher's role being one of the inclusions in the situation (Wiersma, 1991).

Developmental research:

Developmental research is a collective name for longitudinal, cross-sectional and trend or prediction studies (Cohen and Manion, 1989). Cohen & Manion (1989) again indicate that the word had been applied in historical, sociological and psychological phenomena. The terminology used in this type of research is:

- "trend study, cohort study and cross-sectional (longitudinal) study" (Cohen & Manion, 1989:70).

Longitudinal studies is a variety of studies that are conducted over a period of time. Such studies are termed cohort studies in British literature while, in U.S.A. that is called panel study (Cohen & Manion, 1989). Trend studies is when few factors are selected and studied continuously over a period of time.

Ex post facto research:

This is a type of research conducted on things that have taken place in the past. In conducting such a research the researcher needed to know the causes of such things that have already happened. Mason and Bramble (1989) give the following disadvantage of this type of research :

- that the researcher had no control over the data that he/she studies.

Cohen and Manion (1989) gives examples of ex post facto research from studies in London, where a researcher wanted to find out how teachers can help children to stop making common errors in mathematics.

Survey research:

Survey research is used to describe aspects of society. It is also used to monitor changes so that people can respond to those changes (Hoinville and Jowell, 1987). Deobold & Van

Dalen's (1979: 286) definition for survey is that it is a "*detailed description of existing phenomena with the intention of employing the data to justify current conditions and practices or to make more intelligent plans for improving them.*"

Mason and Bramble (1989) explains survey as being used to study the distribution of characteristics in a population. Research techniques which are mostly used in survey are interview, questionnaire, observation and sampling.

Triangulation research:

Triangulation as defined by Cohen & Manion (1989) is the use of two or more methods to collect data for a research study.

Correlation research:

This is the method used during the study of the relationships between phenomena. Mason & Bramble's (1989) example of this type of research is about a person' scores in a mathematics test in comparison with his mathematical skills on the job market as an accountant. Doing this comparison will be correlation studies. Statistics is mostly used in correlation studies.

Action research:

The researcher understand this type of research to be composing of an 'action' and a 'research'. It is a research designed to uncover the effective ways of dealing with problems in the real world (Mason & Bramble, 1989). Example of action research can be given about a teacher in class where, as he/she teaches he/she is researching - the repetition of a lesson will differ after the teacher discovered that the methods used previously hinders the children's learning.

Cohen and Manion (1989:217) indicate that action research is concerned with the "diagnosing of a problem in a specific context and attempting to solve it in that specific context and it is usually 'collaborative' and 'participatory.'"

4.1.2 The case study

The basic methodology of this research is that of the case study. In the researcher's view case study is a field study. It is an in-depth study or considerations of something. Mason and Bramble (1989:40) agrees with this and say:

"*...usually, case study involve consideration of one person, group, project, institution, agency, or other entity. ... the physician who investigate the condition of a patient is performing a case study.*"

As defined by Deobold and Van Dalen (1979:294), case study is a "*method of organising data for the purpose of analysing the life of a social unit*". The other research methodologies; survey, developmental studies and ethnographies (Wallen & Fraenkel, 1991 and Deobold & Van Dalen, 1979) are described in the previous paragraphs. Content analyses implies an analysis of the written visual contents of a document while in ethnography the researcher observes one or more individuals about their daily activities. In developmental studies the interrelationships of individuals and their development over a period of time are studied. It is also being mentioned that a case study is often used to supplement the survey which is defined as "*focus on numerous factors of school operation and the community's perception of the schools and how they are being operated*" (Wiersma, 1991:166).

It is the responsibility of the researcher to gather pertinent data about the present status and past experiences of the unit, and about the environmental forces that contribute to its

individuality and behaviour. A case study may be made of students or a local school (Deobold and Van Dalen, 1979). In a case study, the investigator does intensive study of a limited number of representative cases. Thus a case study was used because of the following reasons:

- that the researcher wanted to study limited number of children in the use of a teaching method.
- that the researcher did not want to analyse the content nor study ethnography.
- that the researcher did not want to believe in historical data, but wanted to have recent available data.
- that the researcher did not want to make the studies over a long period of time.
- that the researcher wanted to have an in-depth investigations and analysis of the specific results in a limited considerable time.

In this study the researcher studied the cases of children from four representative schools. Their behaviour, learning styles and responses within investigative and constructivist approach employed in their classroom environment were considered. Observations, interviews and tests were used to study representative cases within the control and experimental schools.

4.2. OBSERVATIONS

Refer to Chapter 1 for these.

4.3. TEACHERS' QUESTIONNAIRE AND ITS STRUCTURE

The questionnaire was one of the techniques the researcher used to collect appropriate data. The questionnaire method was chosen for the following reasons:

- the self-administered questionnaire does not require interviewers and therefore it saves costs. (Sheaffer et.al, 1979; Bailey, 1982).
- the person administering the instrument has an opportunity to establish rapport, explain the purpose of the study and explain the meaning of items that may not be clear (Best and Kahn, 1986). The present researcher administered 88 questionnaires in order to establish a good rapport, and 35 questionnaires had to be distributed by post while 51 were distributed by colleagues in the subject advisory services of the department.

The questionnaire was given to teachers from both PMP project schools and control schools in order to establish a sound comparative basis. The questionnaire comprises of a group of sixteen multiple choice questions, followed by a second group of five detailed responses questions. See Appendix 4.3.1 D on page 147 for the teachers' questionnaire.

4.3.1. The multiple choice questions:

This section was composed of questions to be answered according to a five-point scale. Respondents were to cross a number indicating their level of agreement with the statement opposite each question.

Example of scale:

1 - I disagree strongly.

2 - I disagree.

3 - I am not sure.

4 - I agree.

5 - I agree strongly.

The questions were further grouped into four subject areas, and each had four questions. The subject areas were: Standards, Support, Teaching approach and Attitudes.

Refer to Appendix 4.3.1 D on page 147.

4.3.2 Detailed response questions:

The questions were designed to obtain general views about the constructivist/investigative approach from the teachers and principals. For example, responding teachers were asked to give detailed information about the things they do in class, whether they like or dislike the approach, and also what they think is of major importance in mathematics education.

4.3.3 The objectives in designing these questions were:

i) To find out whether those questioned think that investigative teaching has changed or can change the standard of mathematics.

ii) To check whether teachers have sufficient support from others for the approach to be used in their classes.

iii) To find out whether investigative teaching and learning has really changed the pupils' attitudes to mathematics.

iv) To find out what the teachers like or dislike in this approach.

v) To identify problems when the approach is employed in the classroom in mathematics lessons.

4.4. DISTRIBUTION OF TEACHERS' QUESTIONNAIRE:

The questionnaire was distributed to teachers as follows:

- 144 teachers attending courses at different centres. (From project schools and non-project schools).
- 30 teachers from the different schools involved (15 from experimental schools and 15 from control schools).

The following people were also interviewed:

- 2 directors of education who are responsible for primary schools and secondary schools.
- 3 area managers.
- 8 inspectors of schools.
- 40 parents from the four schools, both urban and rural, involved in the research. They were interviewed as follows: 20 from urban area and the other 20 from rural. Each of the control and the experimental schools were represented by 10 parents.

See Appendix 4.4 on page 150 for the interview questions.

4.5. SAMPLING:

The schools participating in the research were sampled as set out below:

Two schools were selected from the rural area, and another two selected from the urban area. Of these four schools, two were designated experimental schools and the other two, control schools. The control schools were not PMP schools and were also not supported by key teachers, while the experimental schools were/are PMP schools which were/are supported in respect of the implementation of the investigative and constructivist approaches. One experimental school and one control school are situated in a rural area while the other two are in a semi-urban area. All the schools involved had children of mixed ability and varying ages: for example, in a grade 2 class one might find children aged from 7 to 10 and up. This situation is especially prevalent in rural schools. The experimental schools and control schools were/are all equipped with teaching and learning aids.

4.6. PILOT STUDY:

A pilot study consisting of test writing was conducted at the four schools. The study involved assessing the results of two tests written by the pupils, a pre-test and a post-test. The pre-test was written during the first year of the project, while the post-test was written during the second and third years by the same standard at each school, but obviously by different children (the first test writers having been promoted to higher standards). Again it is stressed that these were children of mixed ability. See the test in Appendix 4.6.2 F on pages 152.

Let it be clear that the pre-test at experimental schools was administered not before the new method was implemented, but at the end of the first year after the approach was implemented.

The main purpose of the pilot study was to:

- compare performance as reflected in the test results between children from experimental schools and those from control schools, i.e. between those taught through investigative teaching and the constructivist approach, and those who were not.
- find out the approach which produce better pass rate.

The analysis of the results of the pilot study is presented in the next chapter.

4.6.1. Pupils' questionnaire

The researcher prepared a questionnaire for the primary school children and administered it himself. It was given to the pupils of lower primary and higher primary schools. Initially it was prepared to be given to only grade 3's and grade 4's, but after it was tried with one group of lower primary school children, the researcher felt that their level of comprehension was too low to produce reliable results. For example, one of the questions stated that: "word problems are difficult"; and the standard 1 and 2 children said 'yes' to this question. The same questionnaire was administered to standard 5 children and elicited considerable (and more plausible) variety of response. It was concluded that, given to grades 3 and 4 pupils, the questionnaire would not produce fair results, as the children are not mature enough to understand the language - even though the questionnaire was administered by the researcher himself. The questionnaire was then administered to

children in standards 3-5.

The aim of giving the children the questionnaire was to find out from them whether in their view they really did what was reflected in responses to the teachers' questionnaire. The results of the questionnaire were meant to supplement those obtained from the teachers' responses. The researcher felt that in educational matters information from both children and teachers is needed to make proper recommendations.

The structure of the questionnaire was as follows:

Items were to be answered by Yes, No and Do not know or Not sure. See Appendix 4.6.1 E on page 151.

4.6.2 Test writing in schools sampled

Two tests were written by the sampled schools. The first test was written in November of the first year of study, and the second in September of the third year of study. These tests were the same tests set and used by Nick James to evaluate the schools in Rustenburg during 1992, and later used by Khulisa management services to evaluate PMP in South Africa. The aim of Nick James's testing in Rustenburg was to determine whether the methods introduced were really improving results in mathematics. In the present case the researcher wanted to find out which strategy - that used in PMP or in the traditional approach - best helped children to pass mathematics. There was also the additional aim of trying to assess the pupils' mathematical understanding and their teachers' performance. The tests can be found in Appendix 4.6.2 F on page 152. They were comprised of the basic operations which are taught to primary school children by all the schools. At the beginning of the project schools weer informed that they would be writing a test at the end of the year

in order to measure performance.

4.7. PERSONAL INTERVIEWS HELD WITH TEACHERS, PRINCIPALS, ADVISERS AND INSPECTORS

Refer to questions in Appendix 4.4 on page 150.

Through the interview the researcher wished to obtain views on issues concerning PMP and mathematics teaching and learning more generally. Informal unstructured interviews were used because the researcher wanted to gain insight into the character and intensity of respondents' attitudes, motives, feeling, and beliefs with regard to mathematics teaching and the changes brought about by PMP in their environments (Deobold and Van Dalen, 1979). The interviews were administered to teachers, principals, advisers, inspectors and directors of education. The teachers and principals were randomly selected while the whole population of advisers and directors was involved.

Samples extracted from interviews with a teacher and a principal are reproduced here to give the reader and idea of how the questions were asked and what sort of response they elicited from the interviewees.

An example from an interview with one of the school principals:

R: What can you say about PMP within your school?

Principal: In PMP more teaching and learning aids are used. These force mathematics teaching and learning to be put in real practice. A lot of improvement is seen in mathematics lessons. Children are no more theorising. (The researcher understood the principal to mean that children are making active use of all their senses in

learning, and not passively looking and listening to the teacher all the time).

R: How do you rate the quality of learning mathematics in your school presently?

Principal: Sir, this has highly improved. For example one of our children in Std 3 named Tshephiso had obtained position 3 in the whole circuit after competing in the mathematics olympiad which is organised annually by AMESA. This is really a proof that the standard of our children in mathematics has changed tremendously.

R: What do you consider as problem(s) for PMP and what do you think can be possible solution(s)?

Principal: Teachers are leaving their classrooms in order to attend workshops and the children are left alone. I suggest that the department should employ more advisers so that one adviser could service a small number of schools, so that teachers could remain at their schools all the time. If more adivisers or key teachers who are paid by the department are there regular visits would be done to schools timeously.

Another example of an interview, this time with one of the assistant teachers who were sampled from a primary school involved:

R: How do you teach mathematics in your school?

Teacher: Our children are taught in groups. Each group is having a group leader who reports after their discussion. The group leaders also help the other children when stuck. The group leaders are not constant, they are always changing.

R: Are your children not undermining one another?

Teacher: No, they respect their colleagues. Our children were trained.

(She meant that the pupils were trained to respect their colleagues and to listen to others when they speak).

R: How can you compare the PMP style of teaching with the way we have been taught?

Teacher: The old approach of mathematics teaching was stereotyped. With PMP, mathematics can come from all around us, from our environment or surroundings, from newspapers, from magazines, etc. PMP teachers learn together with the pupils, that is, children are given a chance to say what they feel and know about something. Mathematics teachers do not only stick to talk and chalkboard-writing.

R: What problems did you as a mathematics teacher encounter in PMP?

Teacher: We never experience serious problems because of our mathematics committee. We always meet to discuss our difficulties. We even meet to discuss our preparations.

R: What advice can you give to the other teachers and officials?

Teacher: I suggest that PMP's investigative teaching and learning approach could be introduced in all the schools in our province and the country as a whole..

The interviews with teachers, inspectors and advisers helped the researcher to identify the following common beliefs:

- That mathematics teaching should start from the pupils' pre-knowledge and surroundings.
- That in mathematics teaching teachers should recognise that pupils learn at different rates and in different ways.
- Pupils should be allowed time to reflect on their own thinking and learning.
- Pupils should be involved physically in the learning process, meaning that they should not just sit and listen to the teacher without asking questions and clarifications.
- Teachers should try by every means possible to encourage their pupils to expand their mode of communicating mathematics.
- That teachers should respond to the children's interests, their concerns and their personal world in mathematics teaching.

- Teachers should recognise the special needs of particular pupils in their classes.
- teachers must use assessment procedures to help them to reflect on investigative teaching and learning in mathematics.
- That the learning environment in classrooms should be healthy and non-threatening, and should encourage the participation of all the learners.
- That the issue of key teachers be supported by the department. The support could be provided by creating posts for primary mathematics subject advisers, who would be in charge of mathematics in the lower primary schools.
- That the Department should construct more buildings in order to accommodate suitable number of pupils per class per subject teacher.

4.8. RELIABILITY AND VALIDITY OF THE TEST

A test was used to measure the effect of a teaching method on the pupils' achievement.

Under Reliability:

The test was earlier used two times, through TIMS project (Appendix 2.1 B on page 133) and also by Khulisa Management for evaluating PMP in South Africa. Both TIMS and Khulisa produced the same results like in the researcher's case. The outcome is that pupils taught in an investigative approach performed better than those taught in a traditional way.

It is felt that the test was reliable because Wallen and Fraenkel (1991:85) say:

> If we used a yardstick to measure a desk three times and obtained different readings each time, we would conclude that the Information was unreliable.

But the same results were obtained three times, meaning that the test is reliable.

Validity:

In schools the objective is that children should pass at the end of the year with knowledge and skills which can help them to cope with life outside school. An achievement test was used to see the performance of the children after the syllabi was expected to be finished. As such the test was on content validity. Borg and Gall (1989) support this idea by saying that content validity is important in selecting tests to use in experiments involving the effect of teaching methods on achievement. It is further emphasised by Best and Kahn (1986) that content validity is based upon careful examination of course textbooks, syllabi and objectives.

A test is a means of measuring the knowledge, skills, feeling and intelligence of an individual or group (Gay, 1981). This research results indicates that the pupils are having knowledge and skills of working mathematics. The analysis of the test results appear in chapter 5.

4.9 PROBLEMS ENCOUNTERED

The researcher came across the following problems:

4.9.1. At the beginning of the research there was the problem of school boycotts caused by strikes in the taxi industry.

4.9.2. Questionnaire which were posted reached teachers late This was indicated by teachers during meetings. This meant that questionnaires had to be re-issued.

CHAPTER 5:

ANALYSIS AND INTERPRETATION

INTRODUCTION:

Data collected through the methods described in the previous chapter is analysed in this chapter.

5.1. QUANTITATIVE / QUALITATIVE TESTS RESULTS

Experimental tests were given to grades 2, 3 and 4 in the two experimental and two control schools. The tests were written on two occasions. The first test was written in November (last quarter) of the first year of the experiment; and the second test written during September (third quarter) of the following year. This means that the children wrote two tests - the first in grade 2 and the second in grade 3. The researcher wanted to identify any differences in the approaches used by the teachers with different pupils in their classes during this time. The following are the results from the schools.

5.1.1. THE RESULTS DURING THE FIRST YEAR OF EXPERIMENT:

GRADE 2: Experimental School 1 and Control School 1 (URBAN SCHOOLS)

	Experimental	Control
Number of pupils	39	69
Average marks	95,6	48,1
Pupils' % Pas	100%	63,8%

GRADE 3: Experimental School 1 and Control School 1:

	Experimental	Control
Number of pupils	25	20
Average marks	84,4	39,0
Pupils' % Pass	96,0%	55,0%

GRADE 4: Experimental School 1 and Control School 1:

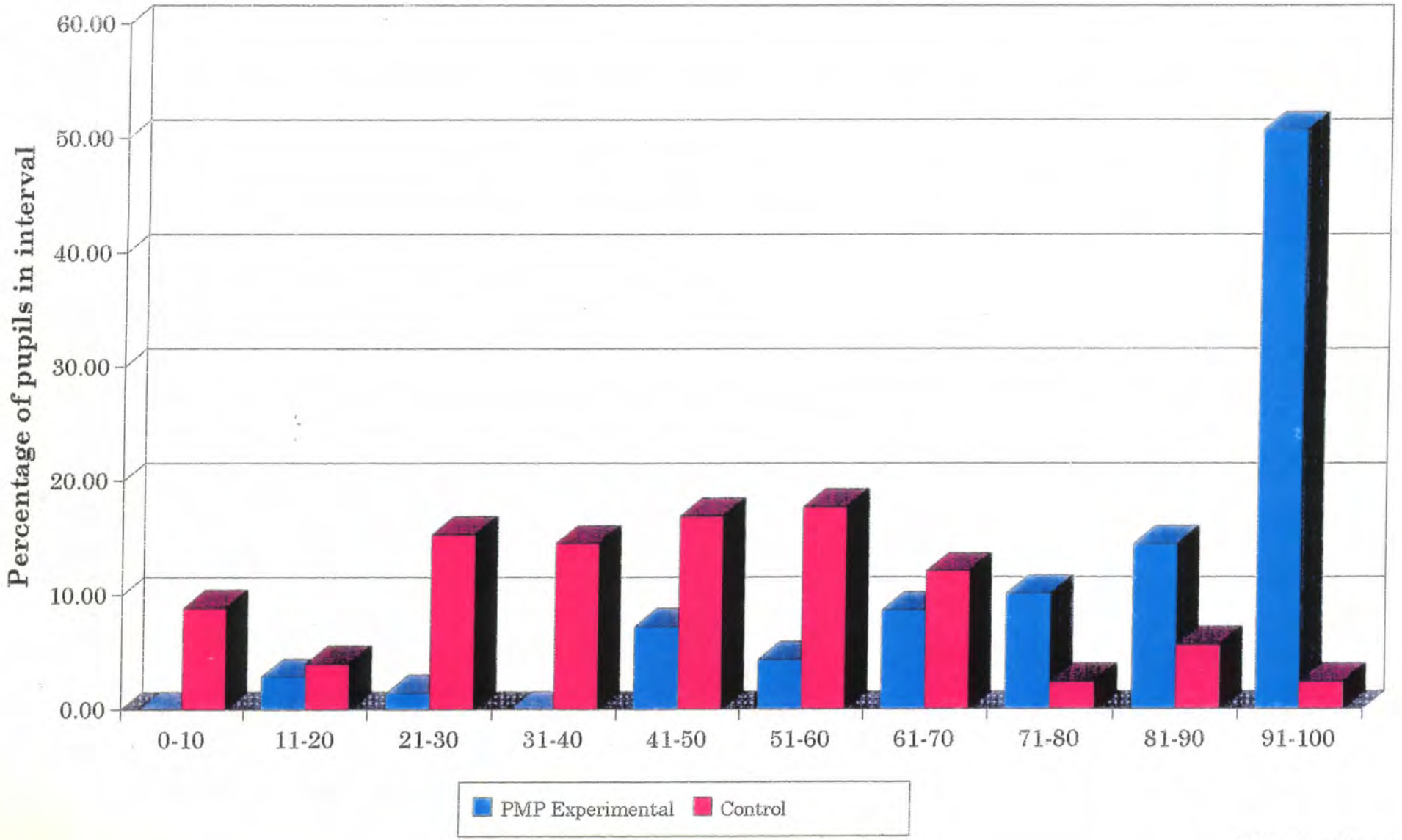
	Experimental	Control
No. of pupils	53	15
Average marks	55,5	32,0
Pupils' % Pass	81,1%	60,0%

NB: Both schools are located in urban areas.

Refer to the graphs on the following pages:

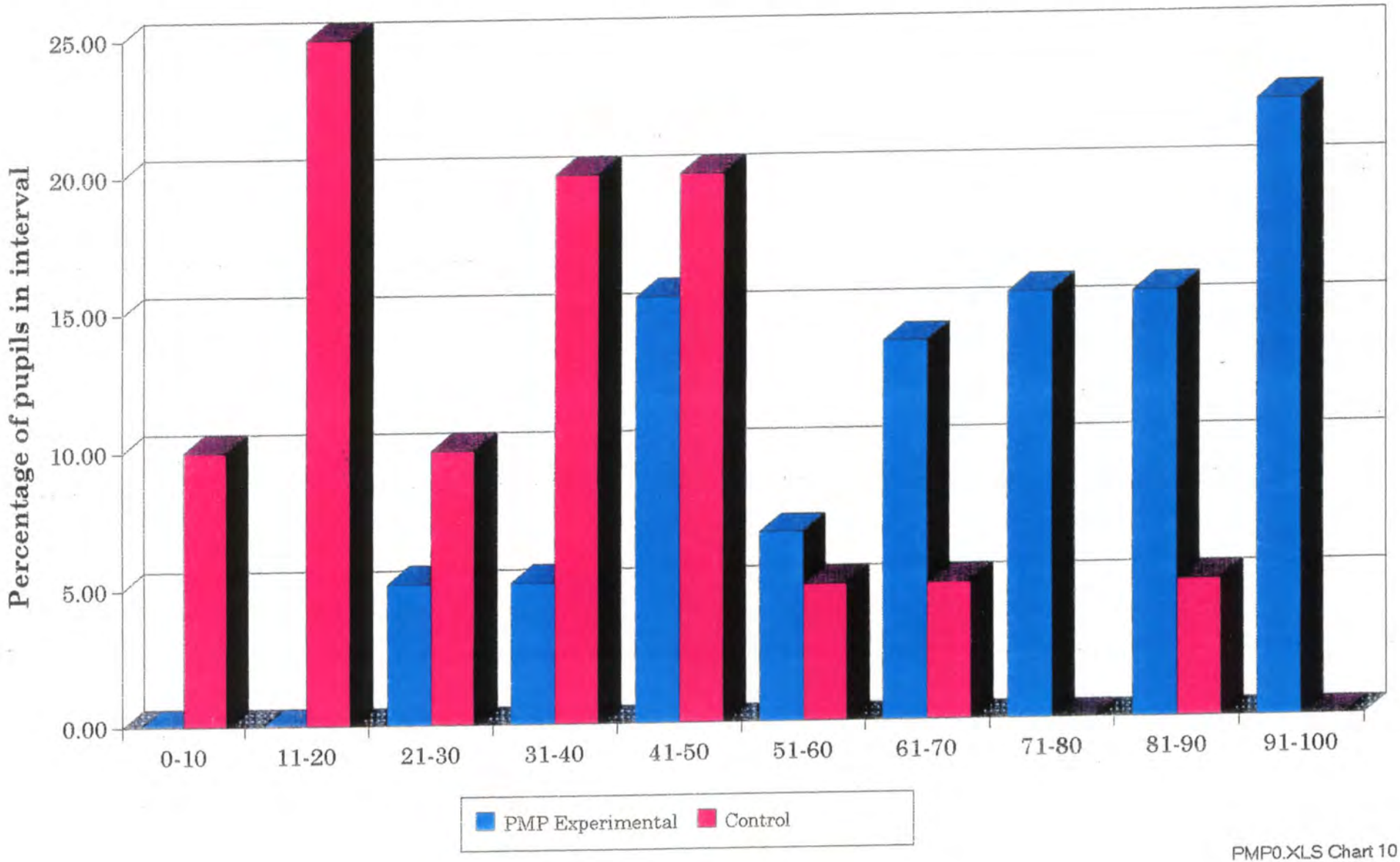
- The first graph on page 76 is for the Grade 2 (SS-B) class.
- The graph on page 77 is for the Grade 3 (Std 1) class.
- The graph on page 78 is for the Grade 4 (Std 2) class.

Experimental and Control Schools: **SSB - Comparison of scores: Total %**



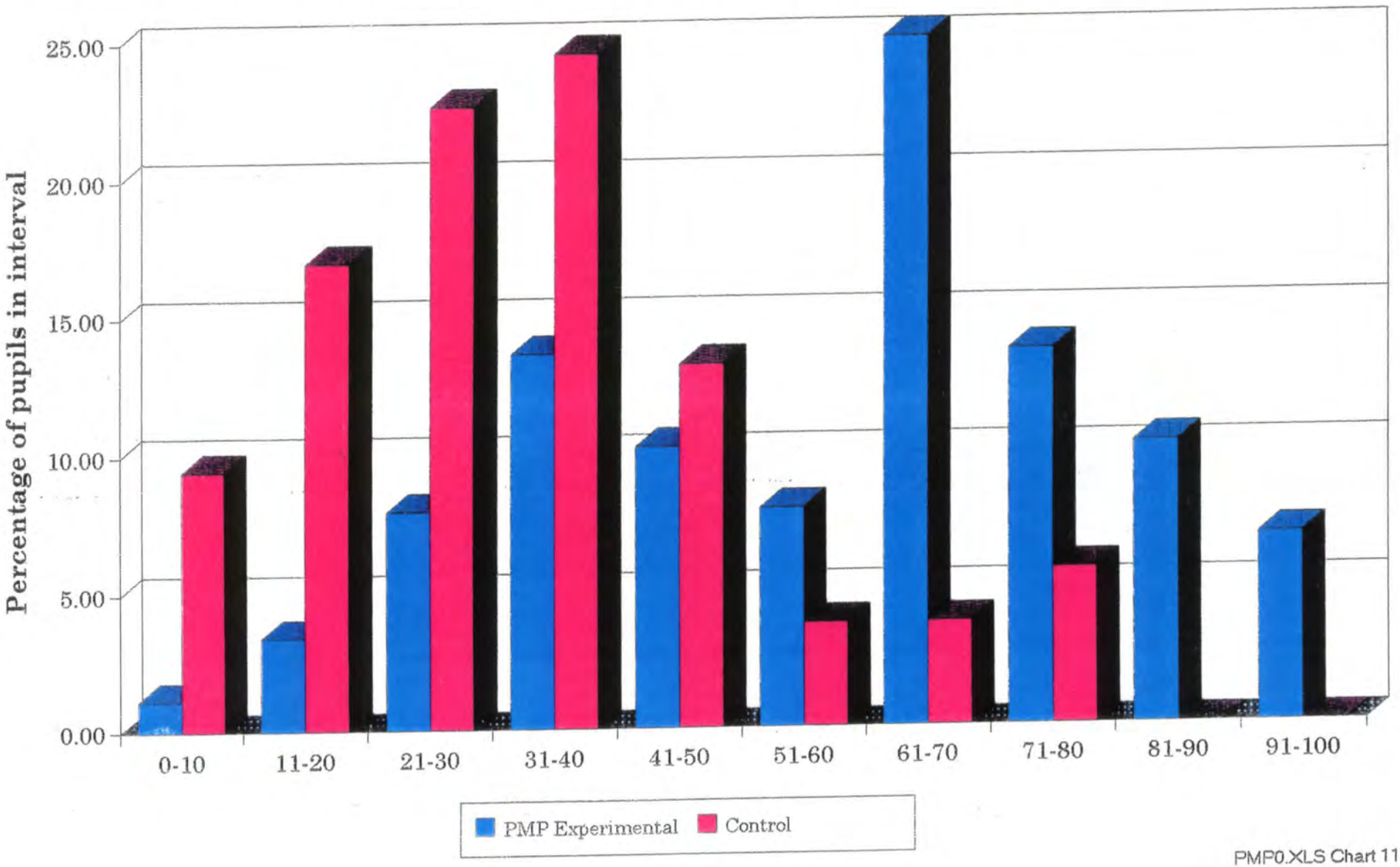
PMP0.XLS Chart 2

Experimental and Control Schools: **Std 1 - Comparison of scores: Total %**



PMP0.XLS Chart 10

Experimental and Control Schools: **Std 2 - Comparison of scores: Total %**



PMP0.XLS Chart 11

Looking at the grade 3 and 4 classes of the two schools, it is clear that the results of the pupils in the control school are much lower than those in the experimental school, even in the case where the class size of the experimental school is greater than the control school. This suggests that the size of the class has little effect on the results in this case.

The second experimental school sampled produced the following results:

GRADE 2: Second Experimental and Second Control Schools (RURAL SCHOOLS)

	Experimental	Control
No. of pupils	29	56
Average marks	71,7	50,0
Pupils' % Pass	90,0%	82,5%

GRADE 3: Second Experimental School and Second Control School

	Experimental	Control
No. of pupils	33	59
Average marks	66,1	38,1
Pupils' % Pass	93,9%	52,5%

GRADE 4: Second Experimental School and Second Control School

	Experimental	Control
No. of pupils	35	38
Average marks	74,0	38,4
Pupils' % Pass	97,1%	47,4%

Refer to further graphical representations for the second experimental and control schools on the following pages; for grade 2 on page 81,

grade 3 - page 82

and grade 4 on page 83.

The number of pupils in classes of the control schools are more than those in the experimental school. The results may be affected by these big numbers, in that teachers in experimental schools would obviously have more time and opportunity to control and guide a reasonable number of children.

Comparing these results with those relating to the first experimental school, it appears that children from the schools using investigative teaching methods are performing well even with big number of children in classes.

5.1.1.1. SOME OBSERVATIONS MADE FROM THE TEST RESULTS OBTAINED IN THE TWO EXPERIMENTAL AND CONTROL SCHOOLS

5.1.1.1(i) First Experimental School versus Control School:

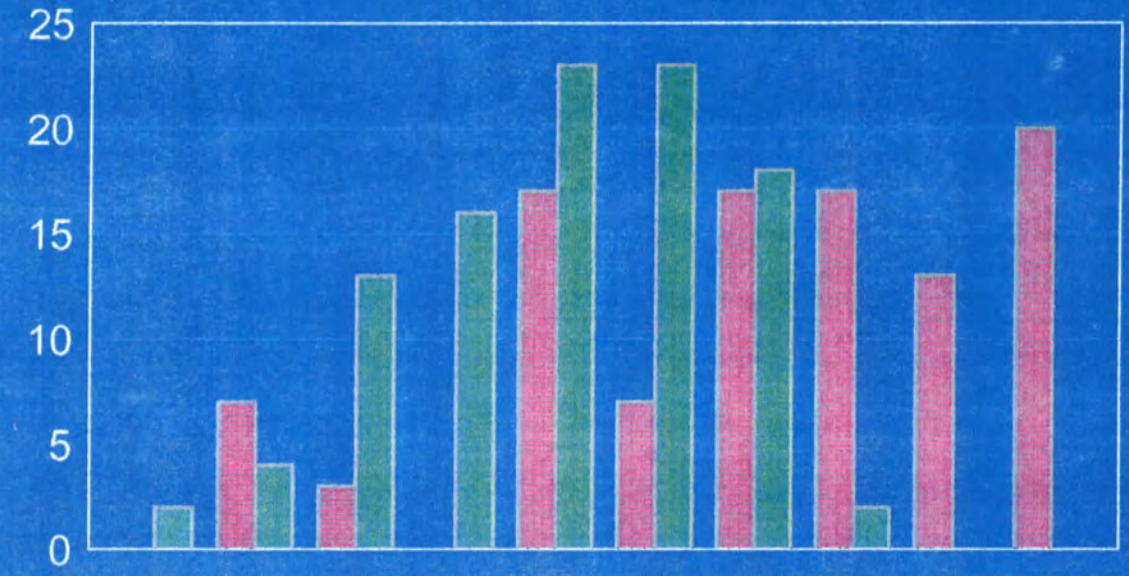
Grade 2

(a) 74% of Experimental School children scored 100% each in the test, while from the Control school 17% of the children only scored between 21% and 30%. A large number of the children from the Control school scored between 0% and 51%.

(b) Through Statistical Checking:

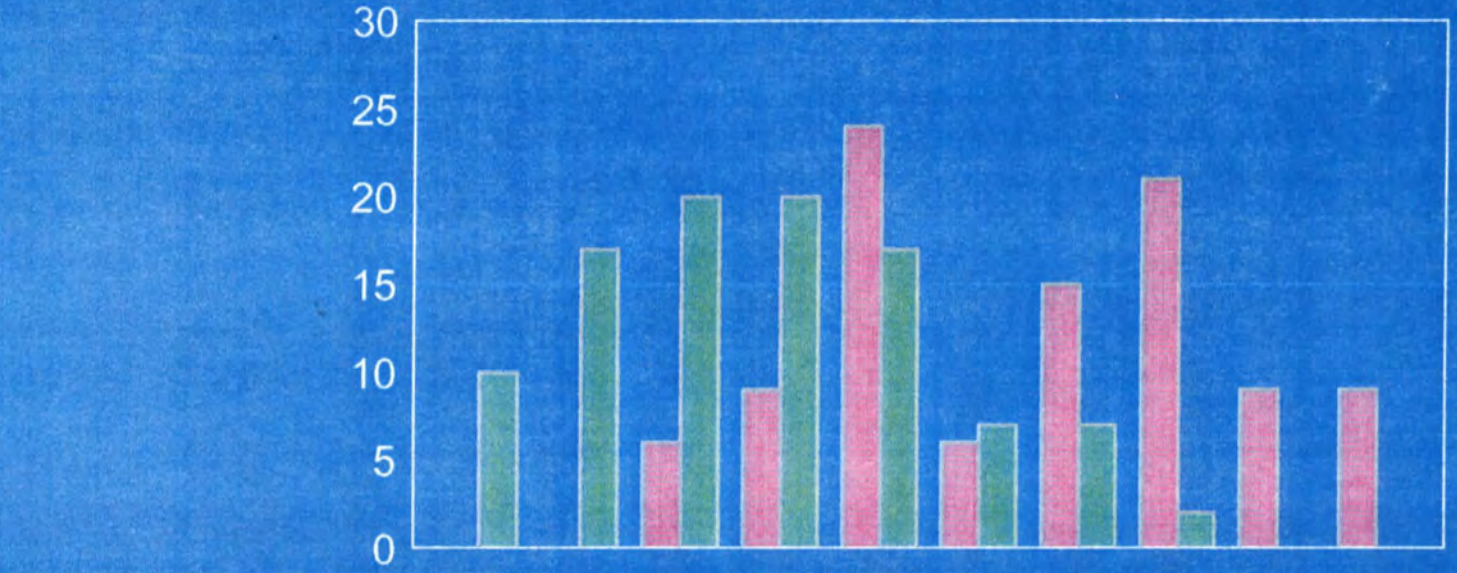
A standard deviation and t-test were used to check the significance of the test results.

EXPERIMENTAL AND CONTROL SCHOOLS NO.2, GRADE 2; % PASS



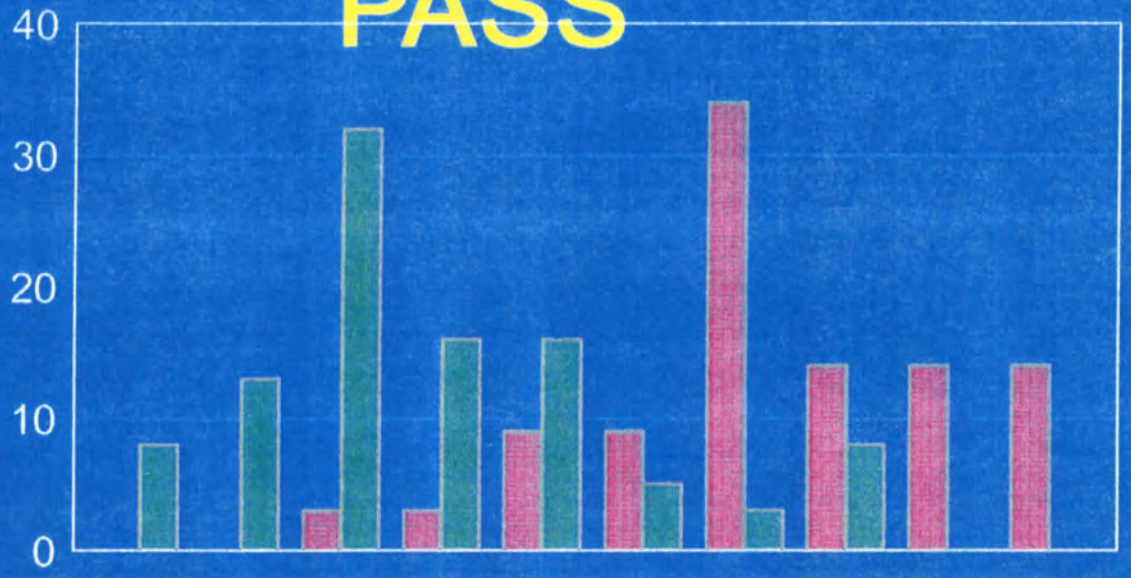
	0 - 10	11 - 20	21 - 30	31 - 40	41 - 50	51 - 60	61 - 70	71 - 80	81 - 90	91 - 100
Experimental Sch. No.2, SSB:29 p	0	7	3	0	17	7	17	17	13	20
Control Sch. No.2, SSB:26 pupils	2	4	13	16	23	23	18	2	0	0

EXPERIMENTAL AND CONTROL SCHOOLS NO.2, GRADE 3; % PASS



	0 - 10	11 - 20	21 - 30	31 - 40	41 - 50	51 - 60	61 - 70	71 - 80	81 - 90	91 - 100
Experimental Sch. No.2, STD 1:33	0	0	6	9	24	6	15	21	9	9
Control Sch. No.2, Std 1:59 pupi	10	17	20	20	17	7	7	2	0	0

EXPERIMENTAL AND CONTROL SCHOOLS NO.2, GRADE 4; % PASS



	0 - 10	11 - 20	21 - 30	31 - 40	41 - 50	51 - 60	61 - 70	71 - 80	81 - 90	91 - 100
Experim. Sch. No.2 Std2:35 pupil	0	0	3	3	9	9	34	14	14	14
Control Sch. No.2 Std 2:38 pupil	8	13	32	16	16	5	3	8	0	0

Standard deviation is a statistical measure which reveals how the marks of the children are scattered; e.g. greater standard deviation indicates that the marks are lying far from the mean, and smaller standard deviation indicates that they are clustered around the mean. Ary, Jacobs and Razavieh (1972) defines it as an index of the degree of spread among individuals in a population. The significance of standard deviation with regard to this research was to indicate how the marks of the pupils are scattered.

T-test is used to determine whether a single mean, proportion, or correlation coefficient differs significantly from a specified population value (Borg & Gall, 1989). The significance of this is to agree or reject the null hypothesis. In this research the t-test value was calculated and found to be 8,1036 which is greater than the table value with a df (degrees of freedom) of 43. When the t-test value is greater than the table value the null hypothesis is rejected.

The average (mean) of the Experimental School pupils was 95,6%, while that of the Control school pupils was 48,1%. Calculating the standard deviations of these schools it was found that 8,9 is for the experimental school while 27,9 is for the control school respectively. Through the t-test we see that the worst performing children in the Experimental school are as good as the best performing children in the Control school.

(c) Testing the Null Hypothesis:

An hypothesis is a logical supposition or a reasonable guess which may give direction to your thinking with respect to a problem and thus help in solving it (Leedy, 1980). If the guess is formulated in a negative way it is called a null hypothesis; for example, if I say that there is no difference between the children being taught through the traditional approach and those taught through problem solving and investigative teaching, this is a null hypothesis.

The null hypothesis is rejected. There is a significant difference between the results of the tests written by children taught through the investigative approach and the children taught through the traditional approach. There is 95% level of confidence that children taught using an investigative approach perform better than those taught using the traditional approach.

Grade 3:

(a) 40% of the pupils from the first Experimental school got 100% in the test, while from the control school only 5% got marks in the interval 81 - 90. Only 4% of the pupils from the first Experimental school failed the test, compared to 45% from the Control school who failed. Most of the marks were collected in the interval 81 - 100 from the Experimental School, while from the Control school most of the marks lay between 31 and 50.

(b) Statistical Checking:

The averages of the two schools are as follows: 84,4% for Experimental School and 39,0% for the Control School.

(c) Testing the Null Hypothesis:

The t-value gave a figure of 8,103 which allows us to reject the null hypothesis. It is concluded again that there is a significance difference between the two schools.

Grade 4:

The results in the other grades (standards) were similar.

(a) The null hypothesis, that there is no significant difference between the two groups, is rejected. We are 95% confident that pupils perform well through investigative teaching and co-operative learning.

(b) The t-test shows that the worst of the First Experimental school (30% to 45%, average 55,5%) pupils still perform much better than the average of those in the Control school (3% to 6%, average 32,0%).

5.1.1.1 (ii) The Second Experimental School versus the Second Control School:

The results of the second experimental school (refer to graphs on pages 84 - 86) are very encouraging. Looking at the marks it is clear that in both grades 3 and 4 a small number of children who performed the worst are in the interval 21% - 30%. There was only one child in grade 4 and two children in grade 3 in this category.

5.1.2. THE RESULTS OF THE SECOND TEST ADMINISTERED DURING THE SECOND YEAR OF THE EXPERIMENT

5.1.2.1. Experimental and Control Schools Number 1 (ALL FROM RURAL AREAS)

GRADE 2:

	Experimental	Control
Number of pupils	49	25
Average marks	96,3	50,0
Pupils' % Pass	100%	80,0%

GRADE 3:

	Experimental	Control
No. of pupils	38	67
Average marks	66,7	33,3
Pupils' % Pass	97,4%	34,3%

GRADE 4:

	Experimental	Control
No. of pupils	51	48
Average marks	67,1	40,4
Pupils' % Pass	94,1%	62,5%

5.1.2.2. Experimental and Control schools Number 2 (ALL FROM URBAN AREAS)

GRADE 2:

	Experimental	Control
No. of pupils	49	53
Average marks	49,3	43,7
Pupils' % Pass	87,8%	58,5%

GRADE 3:

	Experimental	Control
No. of pupils	58	22
Average marks	61,5	40,4
Pupils' % Pass	96,6%	59,1%

GRADE 4:

	Experimental	Control
NO. of pupils	50	14
Average marks	62,5	39,6
Pupils' % Pass	94,0%	50,0%

OBSERVATIONS BASED ON THE ABOVE RESULTS

From the results of the second test we can again see that the children in the experimental schools outperform those in the control schools. Different children have written different test for their different standards. These tests were administered to grade 2, grade 3 and 4 in different years, and at different levels. Through these tests the researcher is convinced that children taught through investigative teaching and co-operative learning methods are performing better than the children who are taught using traditional methods. Even when the

classes are large, the results are unaffected. For example, in the second test one notes that pupils of grades 3 and 4 in the control school are considerably fewer than the pupils in the experimental school, yet the results of the experimental school are better than those of the control school.

5.2. QUESTIONNAIRE ANALYSIS

5.2.1. Teachers' Questionnaire

A: MULTIPLE CHOICE QUESTIONS (SECTION A TO E)

This section of the questionnaire was divided by subjects into four subsections, with each subsection containing four multiple choice questions. The subjects covered were pupils' levels and standards, support, teaching approach and attitudes.

SECTION A: STANDARDS

Questions 1 - 3:

1. The mathematics quality of the pupils leaving this school during the past years was very high.				
Disagree Strongly	Disagree	Not Sure	Agree	Agree Strongly
6,3%	31,6%	24,7%	28,2%	9,2%

Only 37,4% of the teachers indicated that the quality of their pupils' mathematics in previous years was satisfactory. 24,7% did not know whether they were producing good results. This is a strange spread. The researcher expected that many teachers would have said that their children were performing well. However, from reports written by mathematics advisers and inspectors, it seems that mathematics is one of the subjects which are poorly taught throughout the region.

2. After I started using an investigative teaching approach the standard of mathematics on my children has improved.				
Disagree Strongly	Disagree	Not Sure	Agree	Agree Strongly
0%	4,6%	13,2%	50,0%	31,6%

The results reflects teachers' belief that there has been an improvement in the children's level of mathematics understanding and learning. From the daily classroom exercises given and the written tests a clear difference can be discovered. However, most teachers only "agree" and not "strongly agree", even having started to use the approach. It may be

that they are not very sure whether the change is real because of the new methods of teaching; or is it because of them having teaching experience?

3. The mathematics results in my class are better than in previous years.				
Disagree Strongly	Disagree	Not Sure	Agree	Agree Strongly
1,1%	10,3%	19,5%	45,5%	23,6%

These impressions correlate with the test results in indicating an overall improvement. It is interesting to note that most teachers only agree and not strongly agree, as was seen in the previous question. Refer to Appendix 4.6.2 F on page 152 for the structure of the tests.

The table for factor A (Totals) is indicated by the following figures:

Definitely Disagree	**Disagree**	**Not Sure**	**Agree**	**Definitely Agree**
2,5%	**15,5%**	**19,2%**	**41,4%**	**21,1%**

The impression gained from these figures is that the computational approach is changing The quality of teaching and learning in our schools. The standard of mathematics teaching and learning seem to be improving.

4. At present my professional qualifications are adequate for the classes I am leaching.				
Disagree Strongly	Disagree	Not Sure	Agree	Agree Strongly
2,9%	9,2%	14,4%	43,1%	30,4%

The answers to this question contradict reports from inspectors and advisers. Teachers indicated that they were well qualified to teach the subject, but the complaints from senior officials are that pupils are failing. Besides the question of qualifications, there are other factors which may affect the results, such as laziness, lack of discipline, lack of self-respect, lack of principal support and also governmental support. The researcher suggests that something needs to be done to arouse and motivate the teachers to put more effort into their work to help their pupils to pass.

SECTION B: SUPPORT

Questions 5 - 8:

5. I am supported by my principal.				
Disagree Strongly	Disagree	Not Sure	Agree	Agree Strongly
1,7%	6,9%	13,8%	43,7%	33,9%

While visiting schools for observation the researcher discovered that the consensus among teachers was that principals support them in the process of change in the teaching and learning of mathematics. This confirms the evidence of the interviews with principals, in which they indicated that they were in favour of constructivist and investigative teaching at their schools. What is needed for them (principals) is extra training and improved skills in school management, personnel management and management for change.

From the researcher's experience as subject adviser in mathematics, good schools need proper management and leadership from their principals to support the new approach to

teaching. Well-managed PMP project schools have become better schools all-round compared with most other primary schools. The atmosphere which prevails at such schools should be extended to the rest of the schools in the whole region through in-service training courses for principals and senior teachers.

6. Parents are supporting me in my new approach to teaching mathematics to my class.				
Disagree Strongly	Disagree	Not Sure	Agree	Agree Strongly
9,2%	23,6%	32,2%	21,8%	13,2%

Most parents in black community are illiterate or semi-literate; this is especially the case in rural areas where there are few educational resources outside of the classroom. Most parents can assist their children with little besides encouragement. Through the interviews the researcher was able to find out that very few children are supported at home. The interviews with teachers highlighted that some principals are encouraging parents to keep on checking their children's books even if they do not understand some of the subjects. It is believed that this will influence the child to have love to earning and reading books from early age.

7. My fellow colleague teachers give me good support in teaching mathematics.				
Disagree Strongly	Disagree	Not Sure	Agree	Agree Strongly
2,9%	5,2%	10,3%	48,3%	33,3%

From the responses to this question the researcher learned that 81,6% of the teachers felt supported by their colleagues. There is a feeling that teachers from the new and old PMP

project schools are working as a team. This impression was corroborated by the interviews at the different schools.

8. There are plenty of resources available for me to do investigative work with my classes.				
Disagree Strongly	Disagree	Not Sure	Agree	Agree Strongly
9,7%	9,19%	26,43%	43,67%	10,9%

The statistics reveals that teachers are not sure whether there are resources at their schools and in life as a whole. The idea that the computational approach also trains the child to be able to cope with life as he/she grows had perhaps not been fully assimilated. Practical experience provides abundant resources: when you buy something in a shop you need to calculate and subtract to get the correct change; if you keep chickens, you need to be able to count the number of chickens which are left in the fowl-run and the amount of food to be bought to feed them.

The table for the totals of factor B (Support) is:

Definitely Disagree	**Disagree**	**Not Sure**	**Agree**	**Definitely Agree**
5,9%	**11,2%**	**20,78%**	**39,4%**	**22,8%**

The table indicates that the PMP project is supported. This kind of support needs to come from the department as well as from the community as a whole.

SECTION C: TEACHING APPROACH

Questions 9 - 12:

9. I like to teach the pupils in groups.				
Disagree Strongly	Disagree	Not Sure	Agree	Agree Strongly
1,2%	3,4%	2,9%	47,7%	44,8%

From these results it appears that 92,5% of the teachers like working with groups. The researcher suggests that it is important to assist teachers to develop the skills requisite for controlling group discussions. Teachers should also know their role in the group work situation.

10. I would recommend to other teachers the use of the investigative approach.				
Disagree Strongly	Disagree	Not Sure	Agree	Agree Strongly
0%	4,1%	9,85%	40,2%	45,9%

From these responses the researcher concluded that the overwhelming majority of teachers liked the investigative teaching approach. It is recommended that this approach be introduced to other primary schools in the region, and the country as a whole.

11. I find that word problems help the children to improve their mathematics vocabulary and language.				
Disagree Strongly	Disagree	Not Sure	Agree	Agree Strongly
1,7%	5,2%	8,6%	46,6%	37,9%

The impression gained from these responses is that teachers are in favour of word problems. Word problems improve the pupils' mathematical language and vocabulary. It is suggested that in-service courses be introduced to train teachers in formulating simple word problems for classroom use.

12. The investigative approach works as well for weak pupils / students as for bright pupils / students.				
Disagree Strongly	Disagree	Not Sure	Agree	Agree Strongly
1,1%	8,04%	8,04%	43,7%	39,08%

The responses to this question support the test results, in that pupils at the experimental schools who got mostly low marks are performing much better now that an investigative teaching approach is being used. From these results we conclude that the investigative approach can be used with all types of pupils.

Table for the totals of Factor C on Teaching Approach:

Definitely Disagree	**Disagree**	**Not Sure**	**Agree**	**Definitely Agree**
1,0%	**5,2%**	**7,3%**	**44,5%**	**42,0%**

Traditionally teachers do not teach children word sums. Only figures are taught to pupils in classes. The opposite approach in investigative / constructivist teaching is supported by the fact that life is composed of the language of figures with paragraphs. By reading, writing and analysing the sentences, the child increases his/her vocabulary and language understanding.

The opinions of the teachers who answered the questionnaire with regard to this factor indicated that they are in favour of the investigative / constructivist approach for computational operations.

SECTION D: ATTITUDES

Questions 13 - 16:

13. As a results of using the investigative approach, my attitude as a teacher towards mathematics is now positive.				
Disagree Strongly	Disagree	Not Sure	Agree	Agree Strongly
0,6%	6,9%	10,3%	33,3%	48,9%

From these statistics it can be concluded that the teachers' attitude have changed. What we

are not sure of is whether this will really affect the results in a positive way, although it would seem likely.

14. My children are no longer afraid of mathematics, i.e. they like this subject.				
Disagree Strongly	Disagree	Not Sure	Agree	Agree Strongly
0%	5,7%	12,1%	50,0%	32,2%

The researcher feels that this idea should be further researched to obtain conclusive evidence that children are really no longer afraid of mathematics. The suggestion is that the research should spread throughout the whole schooling system. Although the questionnaire answered by the Lower and Higher primary school children indicated a positive love for the subject on their part, this may decrease as they proceed to higher primary, secondary school and university education.

15. The students like to work in groups.				
Disagree Strongly	Disagree	Not Sure	Agree	Agree Strongly
0,6%	5,7%	2,3%	52,3%	39,1%

Teachers indicated that their pupils liked to work in groups. Group-work can sometimes lead to the children playing and not studying. Teachers should be trained in how to deal with children in groups and discussions. The control and supervision of groups definitely need proper guidance.

16. I enjoy using the investigative approach to teaching.				
Disagree Strongly	Disagree	Not Sure	Agree	Agree Strongly
1,7%	14,4%	20,1%	33,3%	30,5%

The teachers who responded to this question indicated their enjoyment of the approach.

The table for the totals of Factor D is as appeared below:

Definitely Disagree	**Disagree**	**Not Sure**	**Agree**	**Definitely Agree**
0,7%	**8,18%**	**11,2%**	**42,24%**	**37,6%**

Teachers seem to be interested in and to like the new approach to teaching. It will be interesting to see the impact their teaching makes on mathematics teaching and learning in their schools.

SECTION E: DETAILED RESPONSES

In this section the percentage of responding teachers who volunteered the same idea is given in brackets. Ideas which were simply mentioned by a very small percentage of respondents have been left out.

17. THE MAJOR AREA OF NEED WITHIN MATHEMATICS EDUCATION IN SCHOOLS

The following ideas came from teachers on what is important in this field:

1) Children being taught to have a knowledge of the four basic operations. (80% of the responses)

2) Fractions and percentages being very important in life and that they should be seriously considered in schools during mathematics periods. (60%)

3) Mathematics to be taught as a language. (55%)

4) Correlating mathematics and other subjects should form part of everyday presentations in any mathematics classroom situation. This will help the child to cope with the mathematics in his/her environment. (70%)

5) Problem solving forms the key to many mathematics teaching activities. (40%)

6) Overcrowded classes and classes taught under trees should be reduced. (40%)

7) Teaching-aids or learning aids are essential in primary schools. (75%)

8) Geometry teaching should also be emphasised in primary schools. (42%)

18. ACTIVITIES PERFORMED IN CLASS WHEN USING AN INVESTIGATIVE TEACHING APPROACH:

Classroom activities which teachers claimed to perform were the following:

1) Grouping of pupils in small manageable groups of not more than five pupils per group. (85% of the responses)
2) Pupils choosing their own group leaders for the purpose of reporting. (70%)
3) Using flash charts, number cards, bottle tops, cuisennaire rods and other improvised teaching and learning aids. (85%)
4) Allowing the pupils to talk and discuss the work in their different groups or even with the teacher; allowing them to express their own views and own understanding. (65%)
5) Giving regular exercises which involve word problems, with the teacher refraining from giving answers and allowing the children to come up with their own solutions. (50%)
6) The teacher moving from group to group in order to assist the children and encourage them to work together. (40%)
7) Encouraging the gifted children to help their colleagues. (50%)
8) Trying to make mathematics teaching a child centred activity. (25%)
9) Using number value rods to teach fractions. (30%)

19. WHAT TEACHERS LIKED ABOUT THE NEW INVESTIGATIVE APPROACH:

90% of the teachers' responses indicated that they liked the following about the approach:

a) The investigative approach prevents the teacher from rushing over a topic/lesson. It

takes time to introduce a new topic, and the more pupils talk the more they will understand.

b) Pupils understand better when working in groups and being helped by their colleagues than when the teacher is in front of them talking and writing on the chalkboard while they are watching.

c) Because of the freedom of language and communication which the pupils enjoy, they are encouraged to talk and gain confidence in mathematics. The result is a positive attitude towards mathematics.

d) Children can learn while they are playing, e.g. with dice or with measurements.

e) Pupils express themselves on what they have experienced.

f) There is a competitive spirit among the children. Through competition children are motivated to learn. Young children always like to imitate. In competition there is a lot of imitation which implies that learning is taking place.

g) Investigative teaching and problem solving encourages self discovery. The same idea is argued by James (1992).

h) The teacher is forced to prepare lessons thoroughly and to have a knowledge of his subject, with specific objectives. (30%)

i) Children are trained in leadership (20%). This happens when certain children are requested to supervise and report on the activities done in their group work.

20. VIEWS ON WHAT THEY DISLIKED ABOUT THE APPROACH:

a) Children are shy to talk. Sometimes weaker children depend on the more active children. Intelligent pupils pressurise the weak ones and because of that slow learners do not enjoy the lessons. (58% of the responses).

b) The management of an overcrowded class using the approach needs a patient teacher because one can easily become discouraged and resort to the chalkboard and telling method. (80%)

c) The method is time consuming, which makes it difficult for one to reach one's planned objectives on schedule. Considerable time is spent in going from group to group, the arrangement of teaching-aids also takes up a lot of time. (80%)

d) The present curriculum does not favour the use of the approach because a lot of time is needed to complete the syllabus for examination purposes. If children are given a chance to investigate, the syllabus is not covered and that is a disadvantage (40%). Thus a change in curriculum policy is essential.

21. THE DIFFICULTIES OF IMPLEMENTING INVESTIGATIVE METHODS IN CLASSROOM:

Difficulties and problems associated with implementing approach were the following:

a) A failure to control pupils in overcrowded classes - thus difficult to implement the approach. (65% of the responses)

b) Not having enough materials to make teaching-aids that can cater for many children in schools. (70%)

The feeling is that perhaps a way needs to be made for the provision of materials.

c) A period of thirty minutes is not enough to use the approach. It is difficult to visit all groups within the thirty minutes period. (85%)

d) Accommodation under trees creates a poor learning situation. (40%)

e) The medium of instruction causes mathematics to be problematical, especially since the subject is embedded in European culture (45%). Everything mathematical is

brought to the Africans through foreign language. For example in black languages there is nothing like a trapezium or parallelogram. Perhaps it is the way that the subject is presented to pupils that makes it difficult. Hoines (1994) indicates that children are best taught mathematics through their mother tongue. What needs to be investigated is whether their performance in mathematics is actually better than when they are taught in a different, second language.

f) The approach needs a teacher who is patient so that he/she can devote enough time and attention to every child during each session of the lesson. (45%)

g) Classrooms are very noisy where the approach is used. (55%)

h) Teachers are not well trained to supervise co-operative groups learning. (30%)

i) In our province there is nobody with literature on this approach for teaches to refer to. (10%). It may be that it is difficult to get access to the literature because the subject advisers have not yet made an effort to collect key pieces of literature for dissemination to teachers.

5.2.2. Pupils' Questionnaire

Refer to the Tables of responses results in Appendix 5.3 G on page 161. What follows is a summary and interpretation of the primary school children's responses.

5.2.2.1

Question 1: I love mathematics.

Responses:

Grade 4:

Yes	Not Sure	No	Total Responses
82,2%	9,9%	1,9%	161

Grade 5-7:

Yes	Not Sure	No	Total Responses
73,3%	9,7%	12,0%	300

From the teachers' questionnaire results it emerged that the pupils like mathematics. These results confirm that the children are fond of the subject.

5.2.2.2

Question 2: I like to work on mathematics alone.

Responses:

Grade 4:

Yes	Not Sure	No	Total Responses
70,9%	13,4%	15,7%	172

Grade 5-7:

Yes	Not Sure	No	Total Responses
35,1%	8,3%	56,6%	302

Judging from the discrepancy in the Yes responses, two groups of children seem to have interpreted the question differently. They may have understood the question as meaning that only mathematics is to be studied, or as meaning that a child is to be working through the subject individually and not with groups of children.

5.2.2.3

Question 3: I like to work on problems with my friend.

Responses:

Grade 4:

Yes	Not Sure	No	Total Responses
83,1%	8,1%	8,7%	172

Grade 5 - 7:

Yes	Not Sure	No	Total Responses
72,7%	6,5%	20,8%	308

Here the number of NO & YES responses seem to indicate that different classes interpreted this question differently. The young children were more positive than the older ones. Does this mean that the young children find it more difficult to work together in groups? The question requires further research. The suggestion from the researcher is to give the children more word problems to do and to train them to work co-operatively, showing them how they can learn from one another. Working co-operatively together involves discussion groups.

5.2.2.4

Question 4: I like to work on problems in groups.

Responses:

Grade 4:

Yes	Not Sure	No	Total Responses
82,1%	8,7%	9,2%	172

Grade 5 - 7:

Yes	Not Sure	No	Total Responses
73,2%	9,4%	17,2%	310

These responses agree with the teachers' responses which also indicated that pupils like to work in groups. They like to help one another. During the interviews with teachers some

indicated that their children were taught through group work to respect their colleagues and trust them. From our experiences as adults we know that explaining something to someone else necessitates a sound understanding of the matter. It is only logical that children will gain a surer grasp of the subject by discussing it with others.

5.2.2.5

Question 5: Our teacher usually encourage us to talk when doing mathematics.

Responses:

Grade 4:

Yes	Not Sure	No	Total Responses
85,7%	10,8%	3,5%	175

Grade 5 - 7:

Yes	Not Sure	No	Total Responses
81,8%	7,0%	11,2%	313

Talking and discussion are part and parcel of group work. Replies to the teachers' questionnaire indicated that they encourage group work in their classes. Traditional teachers in 1950 - 1960 could not change their classroom atmosphere to allow children to ask questions and to talk. Most of us were taught under conditions where teachers believed that discussion created a noisy, disruptive class. But these results suggest that discussion is productive and that children should be given the chance to talk and work together.

5.2.2.6

Question 6: We often use equipment (materials) in mathematics lessons.

Responses:

Grade 4:

Yes	Not Sure	No	Total Responses
85,3%	8,2%	6,5%	171

Grade 5 - 7:

Yes	Not Sure	No	Total Responses
67,8%	14,4%	17,8%	314

Inspectors suspect that sometimes teachers only make use of equipment when a visitor is there, so as to make a good impression. But in this case the pupils' answers confirm that equipment is being used regularly in mathematics classrooms. It should be remembered that this questionnaire was administered by the researcher in the schools without forewarning, so that the pupils could have been primed to answer in this way.

5.2.2.7

Question 7: Word problems (sums) are difficult.

Responses:

Grade 4:

Yes	Not Sure	No	Total Responses
64,2%	23,9%	11,9%	176

Grade 5 - 7:

Yes	Not Sure	No	Total Responses
30,8%	29,2%	40,0%	305

Word sums are a major problem in mathematics. Many teachers do not have time to teach them mainly because they demand a lot of time. Yet we all know that numbers cannot be effectively taught in isolation, as a purely abstract exercise.

Problem solving involves word sums and children dislike that. But if they are taught mathematics though word sums from the beginning, they will get used to them and never complain of their difficulty. From these responses, it appears that the lower primary children feel that word problems are difficult to a greater extent than the higher primary children. It may be that as they climb up the ladder, they improve their language skills and understand the content of word sums better. In their replies to all the other questions the younger children are uniformly more positive, as Appendix 5.3 G on page 161 shows.

5.2.2.8

Question 8: I know multiplication and division tables.

Responses:

Grade 4:

Yes	Not Sure	No	Total Responses
66,1%	28,2%	5,7%	174

Grade 5 - 7:

Yes	Not Sure	No	Total Responses
55,5%	36,2%	8,3%	312

Mathematics needs knowledge of the four basic operations. The two operations which seem to give a lot of our children problems are multiplication and division. While most of the children who responded to the questionnaire indicated that they have a knowledge of the two operations, a disturbingly high percentage acknowledge that they were "not sure". Teachers should see to it that they involve the pupils in practising the operations. Further research in this area is needed.

5.2.2.9

Question 9: My mother or father helps me at home with mathematics.

Responses:

Grade 4:

Yes	Not Sure	No	Total Responses
77,0%	2,9%	20,1%	174

Grade 5 - 7:

Yes	Not Sure	No	Total Responses
75,9%	6,3%	17,8%	303

From the teachers' questionnaire with regard to parental involvement in mathematics it emerged from most of them that parents were not helping their children. But from these statistics it seems that parents are indeed helping their children. In interviews with some of the children it became clear that in some cases the elder brothers and sisters are helping and not necessarily the parents. When talking with parents it was discovered that it is mostly the junior primary child who is assisted, while the upper higher primary child is not. The reason for this may be that as the child progresses through school the mathematics becomes more difficult, so that most parents cannot cope. This may be because many parents left school after attempting only a low grade of primary school mathematics.

5.2.2.10: **Question 10**

From the sentences the pupils were asked to write on what they feel / think mathematics is. The following ideas emerged:

- 55% of the children mentioned that mathematics helps people to be able to count money.
- Mathematics is important because it is used in baking, sawing and building (20% of the responses).
- "When you do not have mathematics among your subjects you cannot have a better future"; by standard 4 & 5 children (80% of them).
- "Mathematics helps us to know a weather chart"; - from a standard 5 child.
- Through mathematics we acquire a knowledge of time (20% of the pupils from different schools).
- "There must be a lot of people who know this so that they could improve the knowledge of technology in our country, (12 year child in Std 4).
- Mathematicians are having the advantage of visiting different countries (5% of the responses).
- Mathematics is useful because if you pass Std 10 without mathematics as one of your subjects you are not allowed to enter any teacher training institution.
- "I want to study mathematics so that I can be a medical doctor" ; (55% of the responses).
- Mathematics helps us to know the different kinds of shapes - less than 5% responses.
- Knowledge of mathematics help us to be able to measure distance and height - less than 5% responded.
- Mathematics helps us to know our ages (A Std 4 child).

From these answers the reader could see that the children seem to be aware of the

importance of mathematics and its widespread applications. It is for the teachers to try and motivate them, to increase their love for the subject. They need the proper guidance from their teachers, parents and the community as a whole.

5.3. SUMMARY OF THE RESPONSES

5.3.1. The Test Results

The test results reveal that most children from the experimental schools are passing mathematics, while those from the control schools are performing badly. The percentage which is failing in the control schools is passing well in the experimental schools.

The size of the class has no effect on performance when the investigative/constructivist approach is used. The investigative approach produced results so far superior such that it is recommended that the approach be extended to all the schools.

5.3.2. Principals, Teachers, Advisers and Inspectors' Interviews

All the teachers and educators interviewed recommended that the approach be introduced to other teachers in all schools. They recommend that in-service training courses be organised to train teachers on how to implement the constructivist approach and also how to control and deal with pupils learning through group work.

5.3.3. Teachers' Questionnaire

Overall, responses to the questionnaire evinced a positive feeling that the standard of mathematics teaching, the teaching approaches, the support of mathematics and the attitude towards mathematics have all changed for the better since the implementation of the new approach.

An issue which raises a question concerns the teachers who are professionally well qualified but whose pupils are still failing. This is a contradiction. It could be that the attitude of the pupils is dependent on the teacher's influence. Teachers also need motivation, from the department's point of view.

Parents need some training as well; i.e they need to be educated about how to encourage their children to do their home works. It is not all parents who are able to help or to encourage their children at home to read their books. There is a doubt about whether teachers can be said to be good supporters of their children at home. From the interviews it emerged that most of the teachers/principals were not sure whether it is true that parents are indeed helping their young children at home.

The issue of overcrowded classes continues to be a problem, although a major obstacle to successful learning. Nevertheless teachers continue to complain about large classes, and it is clear that more classrooms will reduce the load per teacher and make their task easier.

The assumption is that a class of forty to forty-five pupils will give teachers the

opportunity to deal with fewer groups of children and thus give them more time.

The teachers' responses do coincide with the observations made in schools. Refer to item 1.3.5 for the pupils' working.

5.3.4. Pupils' Questionnaire

Primary children are said to be influenced by the teacher's motivation and love for the subject. From this research we are led to believe that children love mathematics. Can't this love be extended upward into the next levels of schooling? What remains a source of surprise and concern is the children's failure when they go on to secondary schools. Further research needs to be done in this regard.

In order for the researcher to be convinced with the results of interviews and questionnaires schools were visited for observation. Item 1.3.5 indicates the results of such observations. Young children are as well free to express their thoughts in mathematics problems. Teachers are also employing child-centred approach in their mathematics teaching.

5.4. CONCLUSION

The teachers' and pupils' questionnaires were administered in experimental schools as well as in control schools. With regard to the children's results the difference is not clearly seen. All the children indicated that they love to work in groups or they love mathematics. They also said that word problems are not easily understood and they are therefore not favoured.

Teachers feel that teaching word problems help them to relate mathematics to other subjects. The difficulty lies in preparing for the lessons so as to ensure that the link if fruitful. All the respondents believe that mathematics is an important subject. Teachers from both experimental and control schools indicated that the division of children into groups is a problem in large classes. Their attitude towards the subject is similar, all teachers indicating that they loved the subject. It would appear that the subject is taught mostly by teachers with a sound knowledge of arithmetic or mathematics.

The tests were meant to test for mathematical understanding and not necessarily just obtaining the right answer. The high degree of understanding was seen during the observations in schools. In Chapter 1, an example is given of three pupils who have answered a problem differently, i.e. Mankono, Lebogang and Mmabatho. The test questions were put in such a way that even children from the control schools could work them out without difficulty. They were not all of the word problem type. All schools had access to the question paper only on the day of writing. The tests were written at the end of the year and were administered by the researcher at a time when one could assume that the teachers had finished their syllabi. And these tests were only disclosed to the teachers at the same time as the children were writing.

From this analysis several findings were made and implications recognised, which can be used to improve mathematics education. The next chapters will deal with these. The graphs give a clear indication that investigative teaching and learning will produce fruitful results in mathematics teaching and learning in our schools. It seems likely that this approach could profitably be shared with all the other teachers and educators in this new country ruled by the Government of National Unity.

CHAPTER 6:

RESEARCH FINDINGS, IMPLICATIONS FOR EDUCATIONISTS, LIMITING FACTORS AND RECOMMENDATIONS

6.1. RESEARCH FINDINGS

The research findings include the following:

6.1.1. Children who are taught through investigative teaching methods are performing much better than children who are taught through the use of traditional methods. This was seen from the results of the written tests in experimental schools.

6.1.2. Most of the teachers who have been exposed to the approach in courses or through literature are in favour of it. These teachers are inspired to use group work. They recommend its implementation in all schools in the province.

6.1.3. At the experimental schools the teachers are now encouraging discussion and investigation as an integral part of their lessons.

6.1.4. On the subject of whether attitudes of parents, teachers and lecturers are improving, the results are inconclusive and the researcher is not satisfied. This area requires further investigation.

6.2. IMPLICATIONS FOR EDUCATIONISTS

6.2.1. The research findings indicate that many changes need to be effected in mathematics education. Teaching styles and methods need to be reviewed. Colleges of Education also need to change their teacher pre-service and in-service training methods with

respect to mathematics teaching and learning.

6.2.2. Management in schools and classrooms need to be studied. Principals and teachers should be encouraged to do some research on how to manage the changing classroom situation, and also on how to manage the school as a whole in conjunction with community involvement. The researcher suggests that management courses be organised for principals and teachers on how to deal with the new, more democratic classroom situation.

6.2.3. Parental involvement needs to be encouraged. Parents need to be educated on how to help their children at home. This will need the assistance of specialists in the field of education, who should be represented in the parent-teachers' associations.

6.2.4. The researcher suggests further that school buildings need to be improved and enlarged, so that more manageable numbers of children can be accommodated in classrooms: the teacher-pupil ratio must be reasonable. The Department will need to plan and commission the building programme, and also appoint more teachers so that classes can be restricted to a reasonable, controllable number of children, with maximum of 35 in secondary schools and 45 in primary.

6.2.5. The curriculum should be changed to allow room for the use of investigative methods in the classroom. Again for example, in the present curriculum there is talk about electricity and trains, while children in most of the rural areas of our region know nothing about these. The curriculum should cater to local environmental needs and experiences.

6.3. LIMITING FACTORS OF THE STUDY

The following factors had an effect on this study:

6.3.1. Lack of literature in local libraries: In the province there is a shortage of literature on research work in mathematics education. The researcher had difficulty in obtaining literature from foreign (meaning not in the researcher's province) libraries and universities.

6.3.2. Schools boycotts: Because of SADTU strikes during 1993 when the research was started it was rather difficult to visit schools for the collection of data.

6.3.3. Schools involved were all from the black community, with very few resources in comparison to the white schools. By resources that means in most black schools only chalkboard is found while in white schools there are equipment for biology, physical science, agricultural science and other subjects. This happened during the transitional period of the old and the new government of national unity.

6.4. RECOMMENDATIONS

It is recommended that:

6.4.1. Schools be structured so as to reduce the number of children in each class.

6.4.2. More in-service training courses be provided for all mathematics teachers at the beginning of the year, with follow-up courses each quarter. Such follow-up courses could be organised for each area.

6.4.3. Teachers who attend in-service training courses be given support by key teachers to help them implement what they have learnt at courses. In PMP schools, as explained in Chapter 3, expert advice is given by key teachers. These key teachers visit schools to

provide classroom support so that teachers can feel confident in implementing what they have learnt. The recommendation made here is that the government appoint expert mathematics educators responsible for lower primary mathematics, with the sole function of visiting schools for classroom support purposes. One such appointee could perhaps be responsible for sixty lower primary schools or an entire circuit. As field workers educators would spend all their time in schools helping teachers in classrooms. Such a group of experts could be called Subject Advisory Teachers for Primary Mathematics.

6.4.4. Seeing that the primary school children enjoy learning through the use of learning aids, it is strongly recommended that materials production be introduced, that is, that teachers should be trained on how to produce their own equipment. What the department can do is to buy only the basic or raw materials for the schools. A budget should be created for buying such materials for the production of equipment for the schools' local needs.

6.4.5. More primary mathematics teachers should be appointed so that each teacher could teach mathematics to not more than forty children per class. Controlling forty children divided into different groups is not as difficult as when they are seventy-five.

6.4.6. At each lower primary school in the province there be appointed a remedial teacher who can help children with specific problems that need remediation. Such a teacher could also be a guidance teacher.

6.4.7. Children in a mathematics learning situation should not only sit in a way such that they all face the chalkboard. They should rather sit in a way conducive to conversation of dialogue without interruption, e.g. sitting around modular furniture.

6.4.8. More time be set aside for mathematics lessons. It is recommended that the lower primary mathematics period be of a minimum of forty to sixty minutes daily, so that each lesson can be divided easily into activities which will include teacher's exposition,

games, discussion, report back and/or written exercises.

6.4.9. At present our teaching is examination-orientated. Teachers are emphasising what is examinable because of the way the curriculum is designed. It is recommended that the curriculum be re-designed so that teachers are free to be flexible and be creative with new ideas. The curriculum should also favour the use of the constructivist investigative approach.

6.4.10. Parents be advised on how to get involved with the education of their children so that they can help them at home with mathematics problems. Teachers need to make parents aware that they can visit classrooms to see how their children are performing or acting.

6.4.11. Expert teachers teaching mathematics should not be obliged to change subjects frequently (in some schools principals are allocating new subjects to teachers every year). To gain sufficient experience a teacher must teach the subject for a number of years. Furthermore, when in-service courses are arranged, the individual must attend all sessions.

6.4.12. Provincial libraries be equipped with books on mathematics education.

6.4.13. All the lower primary schools mathematics teachers in the province be trained on the use of the constructivist and investigative approaches.

6.4.14. Teachers should be involved in team teaching or cross teaching, i.e. where a teacher is requested by a colleague from a different school to come and teach his pupils. They might wish to gain from a colleague's experience in sections/topics with which they are not fully conversant, and vice versa.

6.4.15. School-based INSET be supported and implemented in different areas, as this will serve to empower the teachers.

CHAPTER 7:

FURTHER RESEARCH ON MATHEMATICS EDUCATION AND CONCLUSION

7.1. FURTHER RESEARCH ON MATHEMATICS EDUCATION

7.1.1. It is recommended that further research be carried out on the question of the medium of instruction, to ascertain which will produce the best results: when children are taught mathematics through their mother tongue, or/and when they are taught through a second language (which is English to black children in South Africa).

7.1.2. Further research on the effects of interviews and dialogue in mathematics teaching and learning.

7.1.3. Long-term research should be done to find out whether the attitudes of people and students towards mathematics is improving or not, and to look for strategies for developing better attitudes.

7.1.4. Research to determine the level or standard where children start to fail mathematics or where their performance begins seriously to deteriorate - this may need to be a long term research project. The results of such research will help to identify the level(s) where the problem(s) start. This will assist mathematicians in keeping mathematics education on track from the foundation phase (grade 1) upward, through to matric.

7.2. **CONCLUSION**

It is believed that the recommendations made in Chapter 6 should be implemented by the Department, with further modification and amplification where appropriate.

The researcher looks forward to meeting mathematics educators and education authorities with a view to discussing these.

REFERENCES:

ANC (1994): A Policy Framework for Education and Training (Discussion Document). Braamfontein: Johannesburg.

Ary, D., Jacobs, L.C. and Razavieh, A. (1972): Introduction to Research in Education. Hartcourt Brace College Publishers: San Diego, New York, Toronto, London and Sydney.

Bailey, K.D. (1982): Methods of Social Research. Second Edition. MacMillan: London.

Ball, G. (1994): Doing, Talking and Explaining (From Mathematics in Schools, January 1994).

Best, J.W. and Kahn, J.V. (1986): Research in Education. Prentice-Hall: New Jersey.

Borg, W.R. and Gall, M.D. (1989): Educational Research (An Introduction). Longman: New York and London.

Brandes, D. and Ginnis, P. (1986): A Guide to Student-Centred Learning. Basil Blackwell: Oxford.

Bridges, D. (1979): Education, Democracy and Discussion. NFER Publishing Company.

Brodie, K. (1995): Small group work; teaching and learning. (A paper presented at the 16th National Convention on Mathematics and Natural Sciences, 9 - 14th July 1995 at Johannesburg College of Education).

Brombacher, A. (1995): Application of co-operative learning in the mathematics classroom. (A paper presented at the 16th National Convention on Mathematics and Natural Sciences, 9 - 14th July 1995 at Johannesburg College of Education).

Bruner, J.S. (1986): Actual minds, possible worlds. Cambridge Mass: Harvard University.

Clements, D.H. and Battista, M.T. (1990): Constructivist Learning and Teaching. (Prepared by Constance Kamii amd Barbara Lewis in Arithmetic Teacher, September 1990).

Cockcroft, W.H. (1982): Mathematics Counts. (Report of the Committee of Inquiry into the Teaching of Mathematics in Schools). H.M. Stationery Office.

Cohen, L. and Manion, L. (1989): Research Methods in Education. (Third Edition). Routledge.

Corwin, R.B. (1993): Doing Mathematics Together: Creating a Mathematical Culture. (From Arithmetic Teacher, February 1993).

Davidson, B.R. and Maher, C.A. et.al. (1990): Constructivist Views on the Teaching and Learning of Mathematics. NCTM, USA.

Deobold, B. and Van Dalen (1979): Understanding Educational Research. McGraw-Hill: New York / Johannesburg.

Doise, W. and Mugny, G. (1984): Social development of the intellect. Pergamon; Oxford / Oxon.

Du Toit, D. (1991): Recent Research and Learning Theories (A Position Paper on a New Mathematics Curriculum for the Primary School, by MASA's Syllabus Committee in 1988). Pythagoras No.26: 40-41, July 1991.

Ernest, P. (1989): Mathematics Teaching. The State of the Art. The Farmer Press; New York, Philadelphia and London.

Gadanidis, G. (1994): Deconstructing Constructivism (From Mathematics Teacher, Vol.87, No.2 of February 1994).

Gay, L.R. (1981): Educational Research: Competencies for Analysis & Application. Charles Merril Publishers: Columbus, Toronto and London.

Haire, A. et.al. (1978): Discussion as a Teaching Strategy. Coloraine: New University of Ulster Education Centre.

Hoines, M.J. (1987): Beginners in Mathematics. (A Vygotskian Perspective). Bergen; Casper Publishers, Norway.

Hoines, M.J. (1994): Begynner - Opplaeringen (Fagdidaktikk for matematikk-undervisningen 1-6 klasse). Bergen: Casper Forlag, Norway.

Hoinville, G. and Jowell, R. (1987): Survey Research Practice. Gower Publishing Co. Guildford, England.

Howe, A. (1988): Expanding Horizons: Teaching and Learning Through Whole Class Discussion. Exerter, Short Run Press; England.

Human, P.G. (1990): A Socio Constructivist Approach to Numeracy for Children and Adults. A paper from the RUMEUS Research Project at the University of Stellenbosch, Stellenbosch.

James, C.N. (1992): Investigative approaches to the learning and teaching of mathematics. (From Mathematics Education for In-Service and Pre-Service Teachers; Shuter and Shooter, Pietermaritzburg).

James, C.N. (1993): Tlhabane Investigative Maths Scheme - TIMS Project sponsored by GENMIM Development Trust. National Productivity Institute, Pretoria.

Jaworski, B. (1989): 'Is' versus 'seeing as': Constructivist and mathematics classroom. (From Mathematics, Teachers and Children edited by David Pimm). Hodder and Stoughton; London and Toronto.

Johnson, D.W. and Johnson, R.T. (1992): What to Say to Advocates for the Gifted. (From Educational Leadership, October 1992).

Julie, C. (1993): The functions sub-curriculum and graphic calculators: where are we heading with the school mathematics curriculum? (Pythagoras 1993 September: 21-25).

Kamii, C. (1990): Constructivism and Beginning Arithmetic (K-2). (From Teaching and Learning Mathematics in the 1990's, NCTM USA).

Keltner, J.W. (1974): Group Discussion Process. Greenwood Press Publishers, Westport.

Khulisa, B.A. (1994): Khulisa Report into PMP Activities. NPI; Khulisa Management

Services, Johannesburg.

Lakatos, I. (1976): Proofs and Refutations. Cambridge University Press.

Laridon, P. (1994): Constructivism and Social Learning. Radmaste Centre, WITS University, Johannesburg.

Leedy, P.D. (1980): Practical Research. Macmillan Publishing Company, New York and London.

Lerman, M. (1983): Degrees of unsolvability; local and global theory. New York; Springer Verlag.

Lilford, D.I. (1995): Co-operative kids. (A report on co-operative learning). From Fair Lady, 5 April 1995).

Loughlin, M.O. (1992): Engaging Teachers in Emancipatory Knowledge Construction. (From Journal of Teacher Education. Nov - Dec. Vol 43 No.5: 336-346).

Mabalane, D. (1994): Social Investigative Approach. (Unpublished CAPME Journal for WITS students). Blair Athol Primary School, Soweto: Johannesburg.

Mason, J. (1989): Geometry: what, why, where and how? Mathematics Teaching No. 129: 40-47.

Mason, E.J. and Bramble, W.J. (1989): Understanding and Conducting Research. (Applications in Education and the behavioural sciences). McGraw Hill Book Co. New York, Tokyo & Toronto.

Miles, M.B. (1970): Learning to work in groups - A Programme Guide for Educational Leaders. Teachers College Press, Columbia University; New York.

Moodley, M., Njisane, R.A., Presmeg, N.C. et. al (1992): Mathematics Education for In-Service and Pre-Service Teachers. Shuter & Shooter, Pietermaritzburg.

Murray, J.C. (1989): Some Typical Characteristics of Pupils' Oral and Written Computations. A paper written from the RUMEUS Project (University of

Stellenbosch Junior Primary Mathematics Project).

N C T M, (1989): Curriculum Standards for School Mathematics. Virginia, USA.

Olivier, A.J. (1989): Handling pupils' misconceptions. Pythagoras 21:10-18.

Piaget, J. (1970): Genetic epistemology. Columbia University Press, New York.

Pimm, D. (1988): Speaking Mathematically. Routledge: London.

Pirie, S. and Schwarzenberger, R. (1988): It's what you say and what you do. Mathematics Teaching No. 123: 58-59.

Polya, G. (1945): How to Solve It. New Jersey, Princeton University Press.

Sebela, M.P. (1991): Discussion in Mathematics Lessons. Unpublished B.Phil (Ed.) Dissertation; Univrsity of Birmingham, England.

Sehlare, B.A. (1993): Constructivist in the Classroom. (From Political Dimensions of Mathematics Education 2 edited by Angelis, Julie and Davis). Maskew Miller Longman; Johannesburg.

Sheaffer, R.L. et. al. (1979): Elementary Survey Sampling. Duxbury Press: North Scituate and Massachusetts.

Simmons, M. (1993): The Effective Teaching of Mathematics. Longman; London and New York.

Skemp, R.R. (1979): Intelligence, Learning and Action. Wiley; New York.

Stoker, J. (1991): Constructing mathematical meaning through language: a way forward in primary mathematics. Pythagoras No. 25: 28-30.

Suggate, J. (1995): Children's informal methods of addition and subtraction. Mathematics in Schools, January 1995.

Sutton, G.O. (1992): Cooperative Learning Works in Mathematics. (From Mathematics Teacher Vol 85, No. 1 January 1992).

Terwel, J., Herfs, P.G.P.; Mertens, E.H.M. and Perrenet, J.C. (1994): Co-operative learning

and adaptive instruction in a mathematics curriculum. (Journal on Curriculum Studies, 1994, Vol 26; No.2: 217-233).

Tonkin, R. (1995): Investigations in primary school mathematics. (From Pythagoras 36, April 1995: 29-30).

Tumagole, M. and James N. (1994): Access and Success in Primary Mathematics: Dramatic improvement in pupil achievement in the Tlhabane Investigative Maths Scheme (TIMS). (Paper read during the 1st National Congress and Workshop of AMESA in July 1994 at WITS University, Johannesburg.

Wallen, N.E. and Fraenkel, J.R. (1991): Educational Research: A Guide to the Process. McGraw-Hill: New York, New Delhi, London and Tokyo.

Wiersma, W. (1991): Research Methods in Education: An Introduction. Allyn and Bacon: Boston, London and Sydney.

APPENDIX 1.1 A: MATRIC RESULTS, NOVEMBER 1989 TO 1994.

		1989	1990	1991	1992	1993	1994
SELF GOVERNING REGIONS	TOTAL:	24244	-	-	-	-	-
	% PASS:	8,9%					
GAZANKULU	TOTAL:	-	3653	3862	3519	3501	3274
	% PASS:	-	3,7%	8,2%	9,4%	10,7%	11,6%
KANGWANE	TOTAL:	-	1178	1552	2094	2481	2950
	% PASS:	-	9,5%	9,2%	7,9%	7,9%	7,7%
KWANDEBELE	TOTAL:	-	1166	1405	1671	2021	2653
	% PASS:	-	4,9%	6,5%	8,2%	5,3%	7,2%
KWAZULU	TOTAL:	-	10972	11842	12641	13785	15965
	% PASS:	-	12,1%	8,9%	11,9%	14,2%	14,2%
LEBOWA	TOTAL:	-	7753	10300	12276	14654	19262
	% PASS:	-	6,5%	6,9%	8,3%	6,7%	7,6%
QWAQWA	TOTAL:	-	1727	1969	2265	2414	2987
	% PASS:	-	6,5%	11,3%	11,8%	11,8%	10,1%
D.E.T.	TOTAL:	14304	17877	24525	28597	33046	41363
	% PASS:	14,9%	10,9%	13,5%	15,8%	14,6%	14,2%
B.V.C.	TOTAL:	9902	12137	12137	13458	15631	18856
	% PASS:	18,4%	13,8%	13,8%	21,7%	18,9%	18,3%
COLOUREDS	TOTAL:	10325	10308	-	10759	11193	-
	% PASS:	54,7%	74,7%	-	66,7%	86,9%	-
ASIANS	TOTAL:	-	-	-	10380	-	-
	% PASS:	-	-	-	76,3%	-	-

SOURCE: RIEP, UNIVERSITY OF ORANGE FREE STATE BLOEMFONTEIN.

TABLE 4: WHITES - STANDARD 10 EXAMINATION RESULTS - MATHEMATICS

SUBJECT	GRADE	PASS HG	PASS SG	PASS LG	TOTAL
1989					
MATHEMATICS	H	13613	3296	69	16978
MATHEMATICS	S		21193		21193
MATHEMATICS	L			2991	2991
COMMERCIAL MATHS	S		230		230
ADDITIONAL MATHS	S	214			214
FUNCTIONAL MATHS	S		2549		2549
1990					
MATHEMATICS	H	13064	3175	67	16306
MATHEMATICS	S		20523		20523
MATHEMATICS	L			2963	2963
COMMERCIAL MATHS	S		267		267
ADDITIONAL MATHS	S	482			482
FUNCTIONAL MATHS	S		2653		2653
1991					
MATHEMATICS	H	14460	3462	79	18001
MATHEMATICS	S	0	21782	0	21782
MATHEMATICS	L	0	0	3026	3026
COMMERCIAL MATHS	S	0	259	0	259
ADDITIONAL MATHS	H	324	0	0	324
ADDITIONAL MATHS	S	0	2	0	2
ADVANCED MATHEMATICS		280	0	0	280
FUNCTIONAL MATHS	S	0	2661	0	2661
1992					
MATHEMATICS	H	11861	0	0	11861
MATHEMATICS	S	0	10588	0	10588
MATHEMATICS	L	1751	1757	71	3479
COMMERCIAL MATHS	S	0	5	0	5
ADDITIONAL MATHS	S	338	0	0	338
FUNCTIONAL MATHS	S	0	0	0	0
1993					
MATHEMATICS	H	11820	0	0	11820
MATHEMATICS	S	0	23111	0	23111
MATHEMATICS	L	1744	3416	3678	8838
COMMERCIAL MATHS	S	0	300	0	300
ADDITIONAL MATHS	S	444	0	0	444
ADVANCED MATHEMATICS		227	0	0	227
FUNCTIONAL MATHS	S	0	2255	0	2255
FUNCTIONAL MATHS	L	0	626	42	668

TABLE 4: WHITES - STANDARD 10 EXAMINATION RESULTS - MATHEMATICS

SUBJECT	GRADE	PASS HG	PASS SG	PASS LG	TOTAL
1989					
MATHEMATICS	H	13613	3296	69	16978
MATHEMATICS	S		21193		21193
MATHEMATICS	L			2991	2991
COMMERCIAL MATHS	S		230		230
ADDITIONAL MATHS	S	214			214
FUNCTIONAL MATHS	S		2549		2549
1990					
MATHEMATICS	H	13064	3175	67	16306
MATHEMATICS	S		20523		20523
MATHEMATICS	L			2963	2963
COMMERCIAL MATHS	S		267		267
ADDITIONAL MATHS	S	482			482
FUNCTIONAL MATHS	S		2653		2653
1991					
MATHEMATICS	H	14460	3462	79	18001
MATHEMATICS	S	0	21782	0	21782
MATHEMATICS	L	0	0	3026	3026
COMMERCIAL MATHS	S	0	259	0	259
ADDITIONAL MATHS	H	324	0	0	324
ADDITIONAL MATHS	S	0	2	0	2
ADVANCED MATHEMATICS		280	0	0	280
FUNCTIONAL MATHS	S	0	2661	0	2661
1992					
MATHEMATICS	H	11861	0	0	11861
MATHEMATICS	S	0	10588	0	10588
MATHEMATICS	L	1751	1757	71	3479
COMMERCIAL MATHS	S	0	5	0	5
ADDITIONAL MATHS	S	338	0	0	338
FUNCTIONAL MATHS	S	0	0	0	0
1993					
MATHEMATICS	H	11820	0	0	11820
MATHEMATICS	S	0	23111	0	23111
MATHEMATICS	L	1744	3416	3678	8838
COMMERCIAL MATHS	S	0	300	0	300
ADDITIONAL MATHS	S	444	0	0	444
ADVANCED MATHEMATICS		227	0	0	227
FUNCTIONAL MATHS	S	0	2255	0	2255
FUNCTIONAL MATHS	L	0	626	42	668

APPENDIX 2.1 B: TIMS PROJECT(PMP)

THLABANE INVESTIGATIVE MATHS SCHEME

TIMS PROJECT

sponsored by GENMIN DEVELOPMENT TRUST

C N JAMES /AF

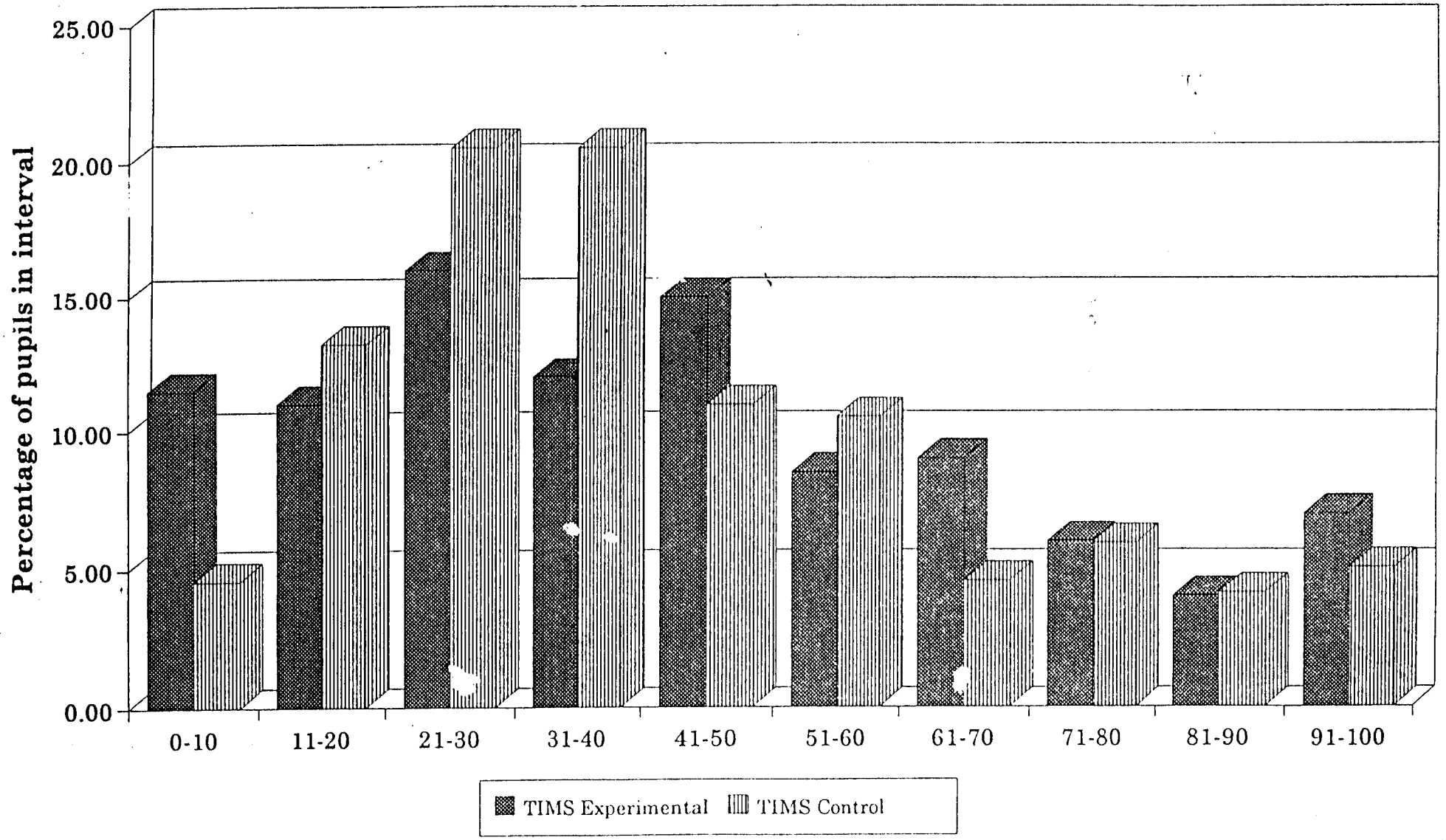
Manager : Centre for Productive Education

National Productivity Institute
Head Office: P O Box 3971 Pretoria 0001 Tel (012) 341-1470 Fax: (012) 44-1866 Telex: 3-20485 SA
Cape Town: P O Box 3004 Tygerpark 7536 Tel: (021) 946-2267/2 Fax: (021) 946-2893
Durban: P O Box 47600 Greyville 4023 Tel: (031) 23-2090 Fax: (031) 23-9909

Nasionale Produktiwiteitsinstituut
Hoofkantoor: Posbus 3971 Pretoria 0001 Tel: (012) 341-1470 Faks: (012) 44-1866 Teleks: 3-20485 S.
Kaapstad: Posbus 3004 Tygerpark 7536 Tel: (021) 946-2267/2 Faks: (021) 946-2893
Durban: Posbus 47600 Greyville 4023 Tel: (031) 23-2090 Faks: (031) 23-9909

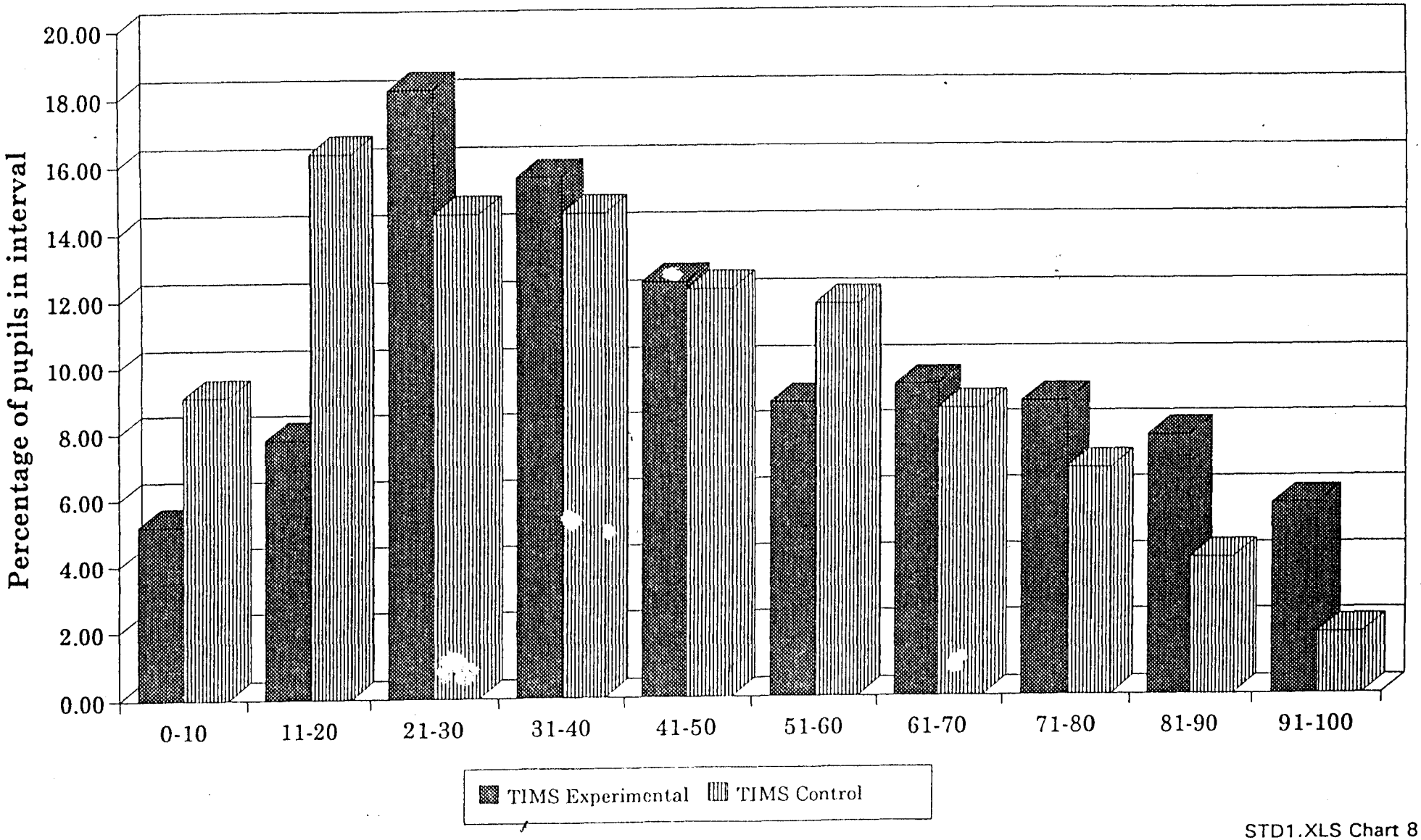
Reg No/Nr. 75/00044/08

Grade 2 - Comparison of scores : Total %



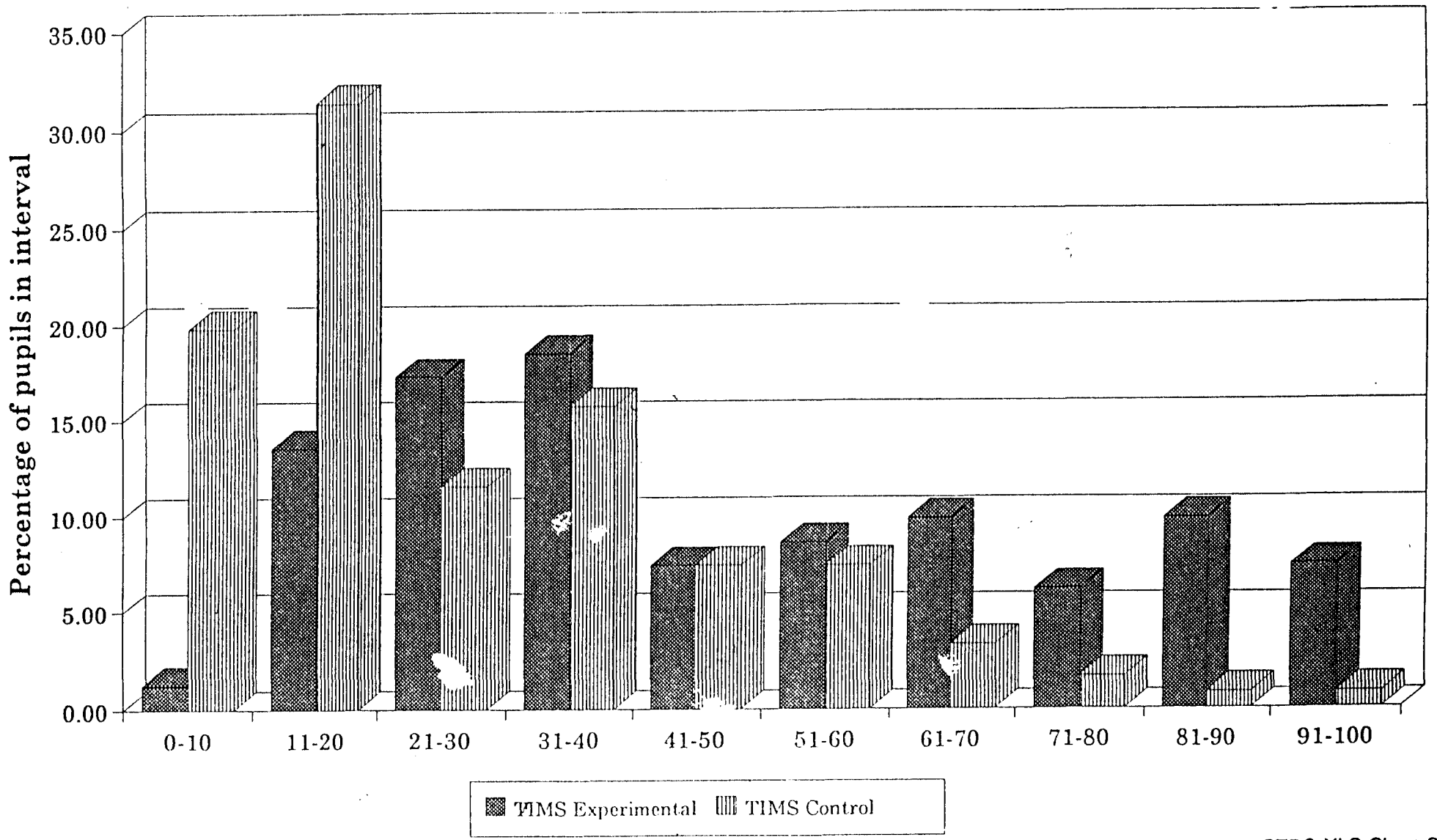
GR2.XLS Chart 8

Std. 1 - Comparison of scores : Total %



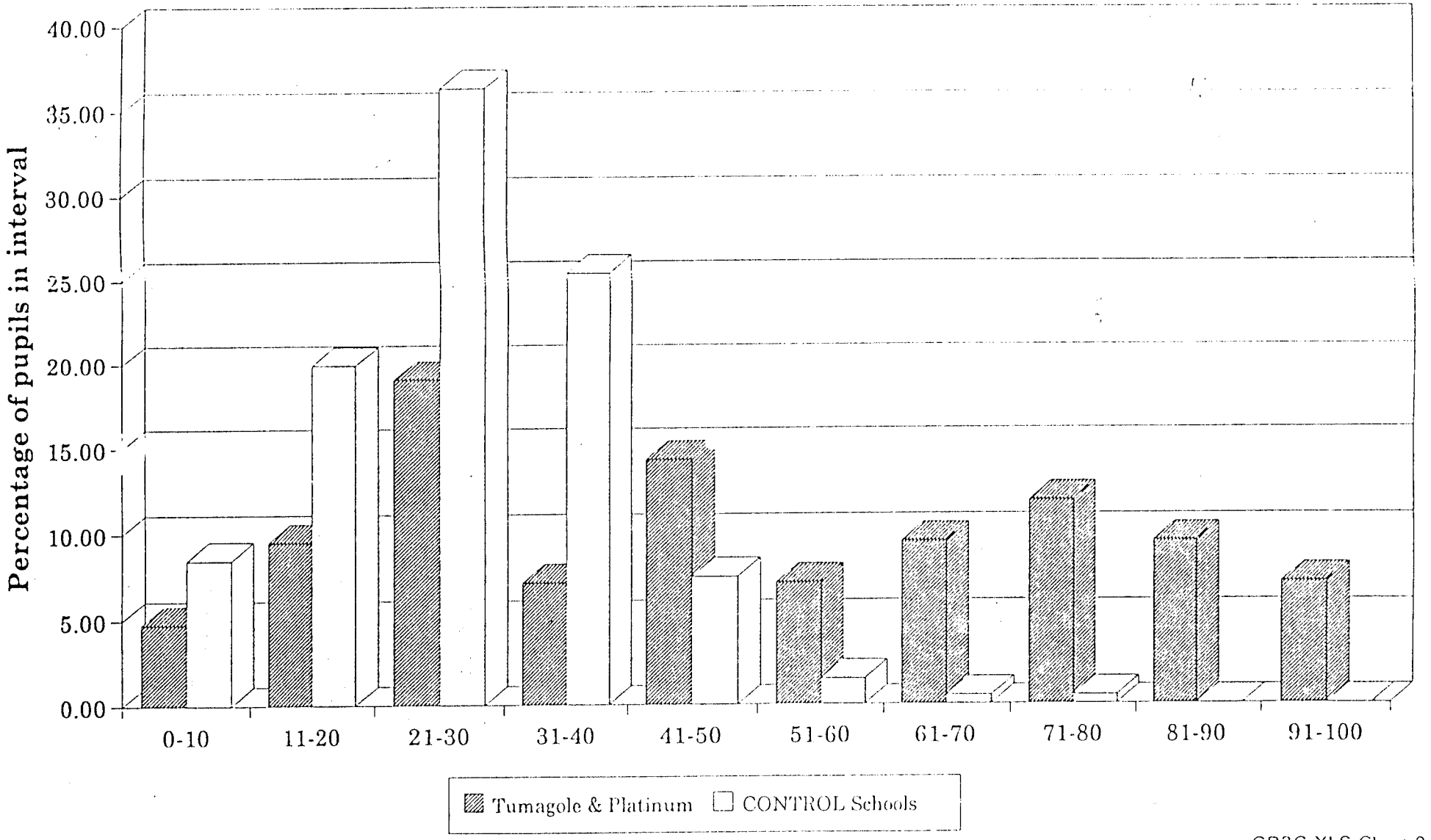
STD1.XLS Chart 8

Std. 2 - Comparison of scores : Total %



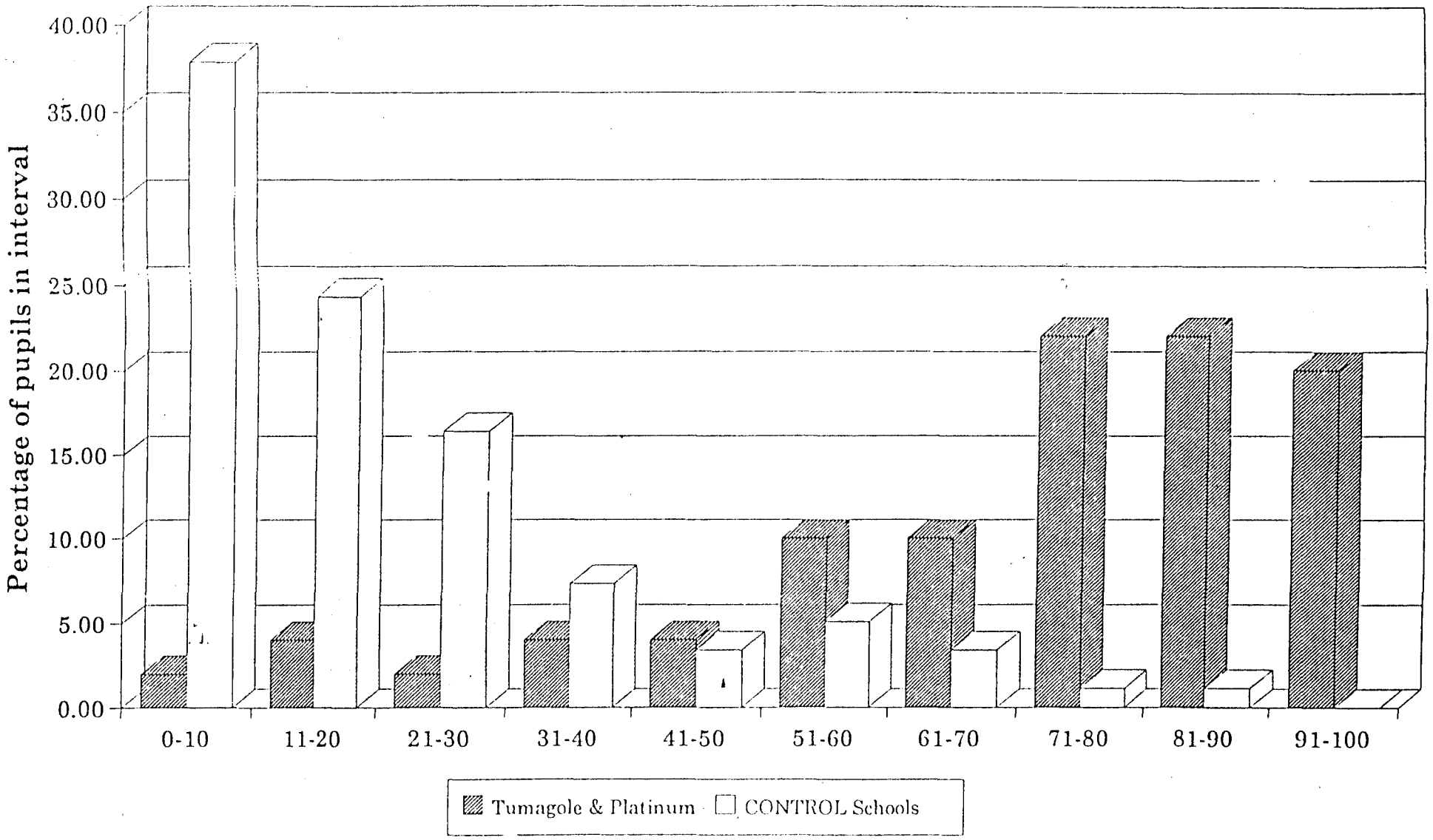
STD2.XLS Chart 8

Grade 2 - Comparison of scores : Total %



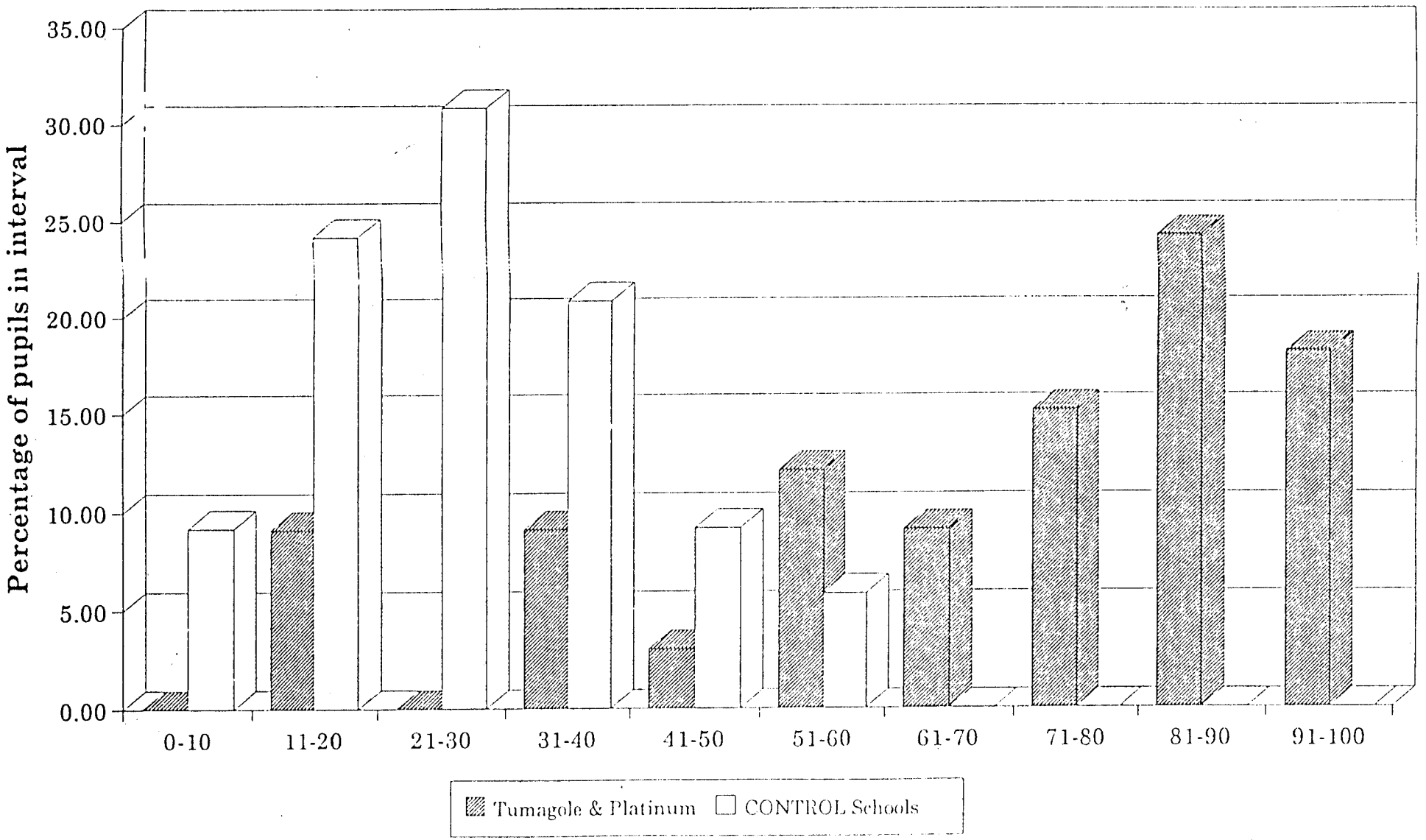
GR2C.XLS Chart 9

Std. 1 - Comparison of scores : Total %



STD1C.XLS Chart 9

Std. 2 - Comparison of scores : Total %



STD2C.XLS Chart 9

APPENDIX 2C: RUMEUS PROJECT (STELLENBOSH)

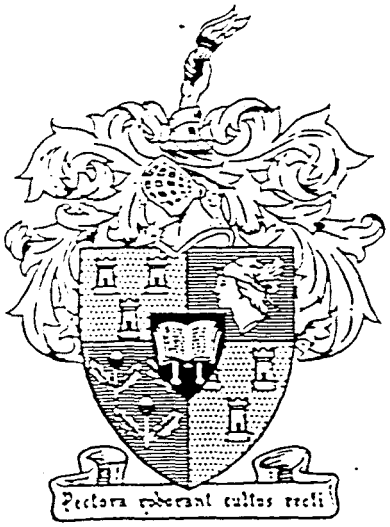
Some Typical Characteristics of Pupils' Oral and Written Computations

Hanlie Murray

Junior Primary Mathematics Project†

Communiqué No. 1

August 1989



†This project is a joint undertaking of the Cape Education Department and RUMEUS.

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Research Unit for Mathematics Education
University of Stellenbosch

1. Computational methods for the same problem vary from pupil to pupil, depending on the level of mathematical thinking of which each pupil is capable *at that time.*

4. 26 + 93 - 18 Claude

26 + 94 → 120 - 19 → 101

26 + 93 - 18 = 101 ✓

4. 26+93-18 Jacobus

20+90-10→100+6→106+3→109-8→101

26+93-18=101 ✓

Lindsay

154 + 265 = 419

100 + 200 → 300

50 + 60 → 110

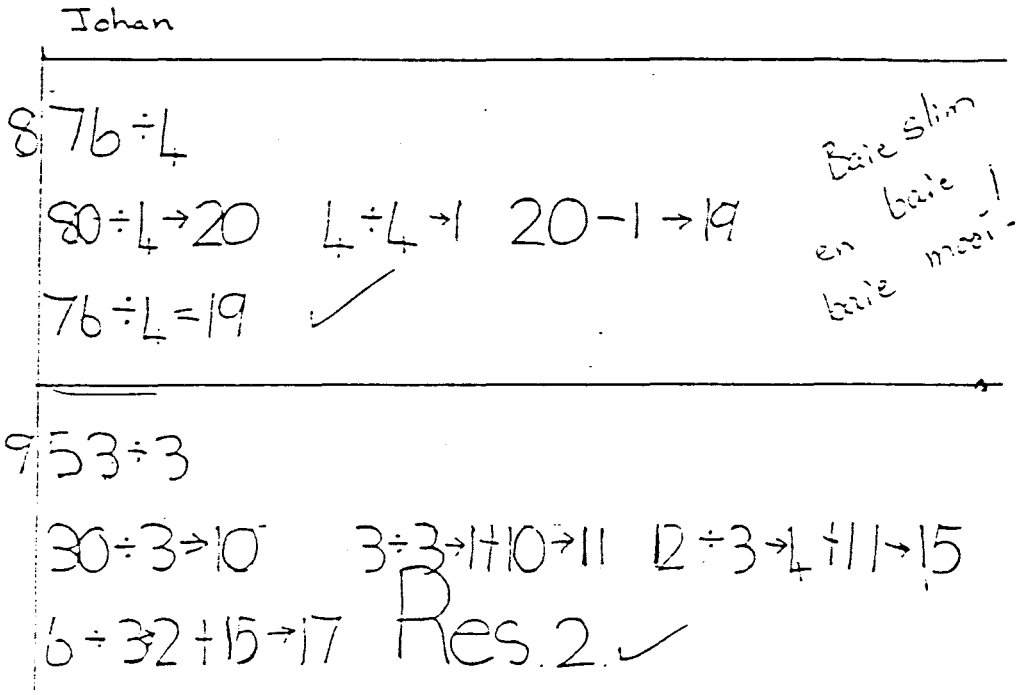
4 + 5 → 9

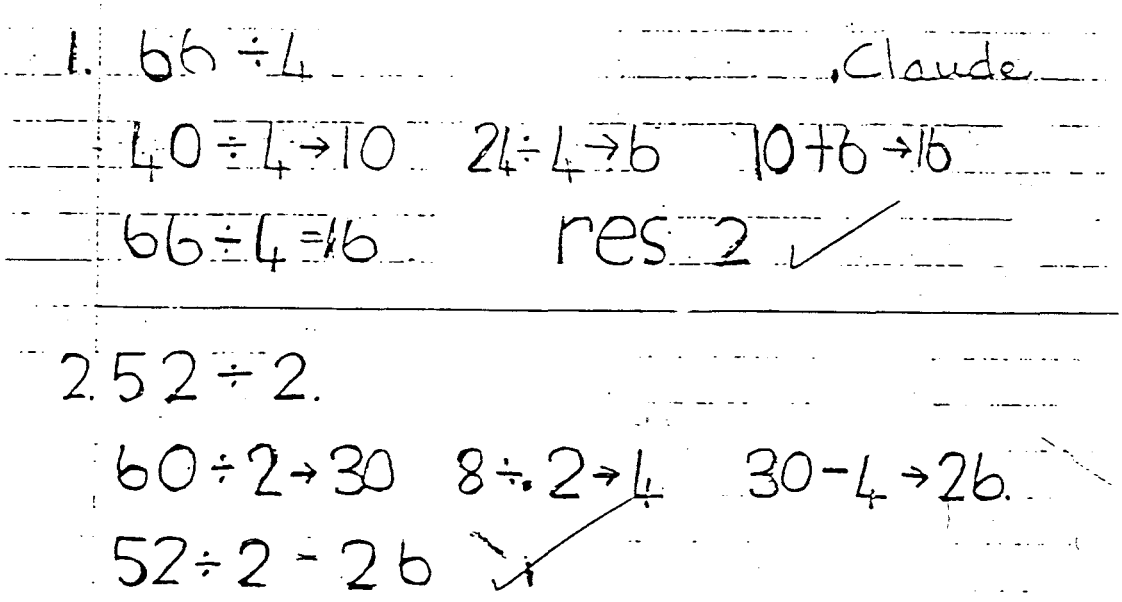
Geoffy

91 - 45 = 46

90 - 40 → 50 1 - 5 = -4 50 - 4 = 46

2. The same pupil chooses different computational methods for different problems, frequently being influenced by the characteristics of the numbers involved.





3. The methods favoured by a particular pupil sometimes mature over a period of weeks (or days) to shorter, more abstract strategies.

2. 96 ÷ 16 Etian, 9.8.89

96 - 5 - 5 - 5 - 5 - 5 - 5 - 5 - 5 - 5 - 5 - 5 - 5 - 5 - 5 - 5 → 16 -1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1

-1-1-1-1 → 0 5 + 1 → 6

96 ÷ 16 = 6 ✓

3. 94 ÷ 13 Etian, 10.8.89

13 + 13 + 13 → 39 + 13 + 13 → 65 + 13 + 13 → 91.

1 + 1 + 1 + 1 + 1 + 1 + 1 → 7.

94 ÷ 13 = 7 Yes 3.

1. 83 ÷ 13 Etian, 11.8.89

13 + 13 → 26 + 13 → 39 X 2 → 78.

1 + 1 + 1 + 1 + 1 + 1 → 6.

83 ÷ 13 = 6 Yes 5. ✓

4. Pupils are required to set out their reasoning processes systematically, and are regularly asked to explain their reasoning. This enables the teacher to gauge each pupil's level of understanding exactly, and insures against copying either answers or methods blindly.

Willem

3. 42÷3

42→40+2 30÷3→10 12÷2→14

ek verstaan nie dit nie.

42÷3→14 Kom vertel vir my, asb

6. 75÷5

Wys asb. hoe jy jou antwoord kry.

75÷5→15

75÷5→15

5. Pupils are unanimously enthusiastic about the freedom to choose their own methods.

Wiskunde 7/1989

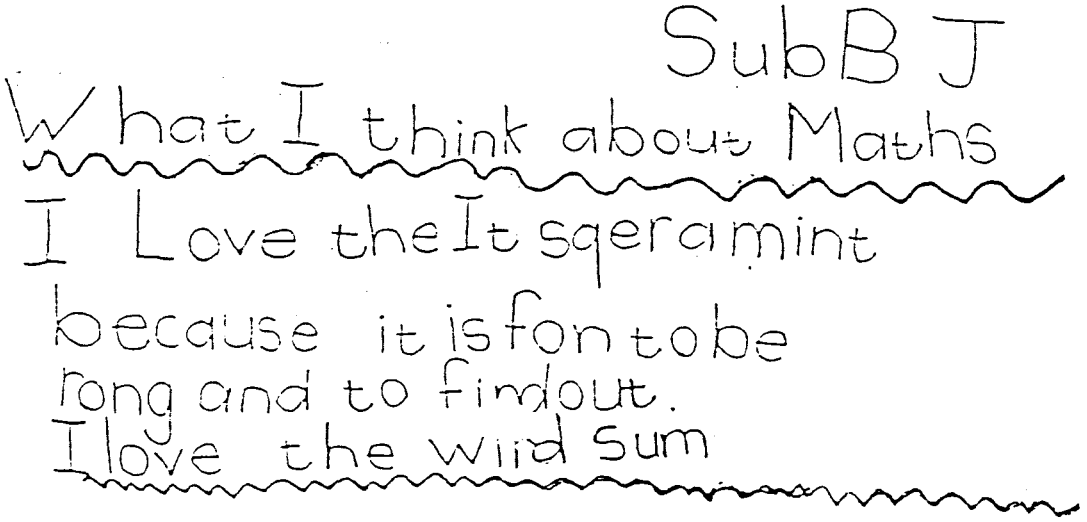
Dit lekker want ek kan dit op my manier doen

8906301 Std 1

Maths in 1989 7/89

I like the way that we are doing now when we can chose wich way to do our maths. I like doing maths because I find it easy I did'nt like it in sub B when the teacher told us how we must work it out

6. Pupils find that setting out their reasoning step by step enable them to discover their own errors. Their attitude towards errors also seems to have changed.



SubB J

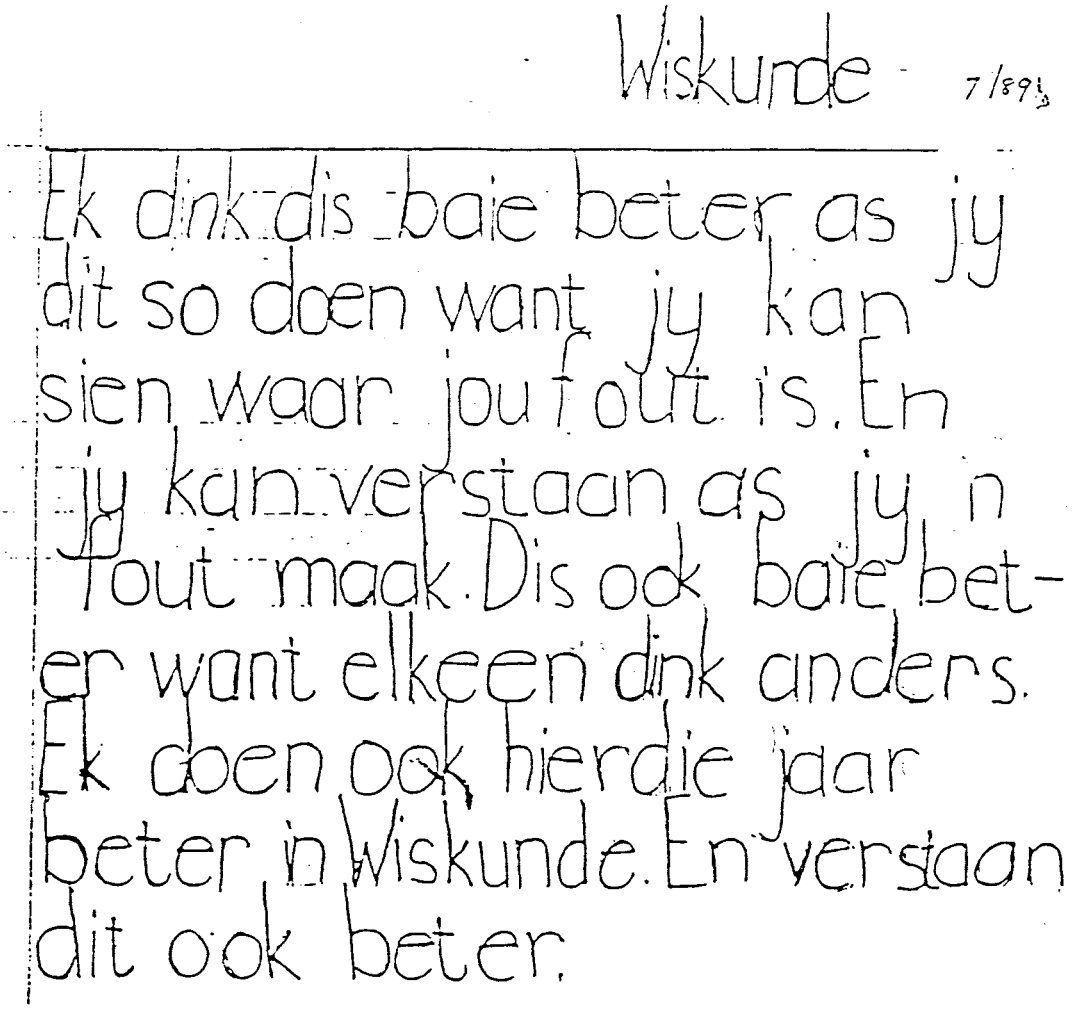
What I think about Maths

I Love the It sqeramint

because it is fon to be

rong and to findout.

I love the wiid sum



Wiskunde 7/89

Ek dink dis baie beter as jy dit so doen want jy kan sien waar jou fout is. En jy kan verstaan as jy n fout maak. Dis ook baie beter want elkeen dink anders. Ek doen ook hierdie jaar beter in Wiskunde. En verstaan dit ook beter.

APPENDIX 4.3.1.D:TEACHERS' QUESTIONNAIRE

TEACHERS' QUESTIONNAIRE:

PLEASE COMPLETE THE FOLLOWING DETAILS:-

SEX: MALE:..... or FEMALE:.....

NAME OF SCHOOL or COLLEGE WHERE TEACHING:.....

YOUR HIGHEST QUALIFICATION IN MATHS:.....
(e.g. Std 8, Matric, Maths I, etc.)

PROFESSIONAL QUALIFICATIONS:.....
(e.g. PTC, PTD, STD, UED, B.Ed; etc.)

YEARS EXPERIENCE IN TEACHING MATHEMATICS:.....

INSTRUCTIONS:
The Questionnaire is divided into five sections, A to E. In answering the items in Section A to D; cross the number which indicates your level of agreement with the statement according to the following scale:-

1 - I definitely do not agree with the statement.
2 - I do not agree.
3 - I am not sure.
4 - I agree.
5 - I definitely do agree.

Example:
Suppose that you think that the current syllabus does not suite your pupils, then you would mark the scale as follows:

The current syllabus is ideal for my pupils. 1 X 3 4 5.

For Section E, Please answer according to your own views with full details.

SECTION A: (Standards):

1. The mathematics quality of the pupils leaving this school during the past years was very high. 1 2 3 4 5.

2. After I started using an investigative approach the standard of mathematics of my children has improved. 1 2 3 4 5.

3. The mathematics results in my class are better than in previous years. 1 2 3 4 5.

4. At present my professional qualifications are adequate for the classes I am teaching. 1 2 3 4 5

SECTION B: (Support):

5. I am supported by my principal.	1	2	3	4	5.
6. Parents are supporting me in my new approach to teaching mathematics to my class.	1	2	3	4	5.
7. My fellow colleague teachers give me good support in teaching mathematics.	1	2	3	4	5.
8. There are plenty of resources available for me to do investigative work with my classes.	1	2	3	4	5

SECTION C: (Teaching Approach):

9. I like to teach the pupils in groups.	1	2	3	4	5
10. I would recommend to other teachers the use of the investigative approach.	1	2	3	4	5
11. I find that word problems help children improve their mathematics vocabulary and language.	1	2	3	4	5.
12. The investigative approach works as well for weak students as for bright students.	1	2	3	4	5.

SECTION D: (Attitudes):

13. As a result of using the investigative approach, my attitude as a teacher towards Mathematics is now positive.	1	2	3	4	5
14. My children are no more afraid of Mathematics, i.e. they like this subject.	1	2	3	4	5
15. The students like to work in groups.	1	2	3	4	5
16. I enjoy using the investigative approach to teaching.	1	2	3	4	5

==========

SECTION E: (Detailed responses):
Please give detailed information:-

17. What do you consider as a major area of need within the Mathematics Education at your school?

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18. What sorts of things do you do in class when you use the investigative approach?
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19. What do you like about the new approach?
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20. What do you dislike about the new approach?.
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21. What are the difficulties in implementing investigative methods in your classroom?
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THANK YOU FOR YOUR TIME AND KINDNESS.

MKGOUSTT.

APPENDIX 4.4.

INTERVIEW QUESTIONS:

(a): FOR PRINCIPALS:

1. What can you say about PMP within your school?
2. How do you rate the quality of learning mathematics in your school?
3. What do you consider as problem(s) for PMP and what do you think can be possible solution(s)?

(b): FOR MATHEMATICS TEACHERS:

1. How do you teach mathematics in your school?
2. Are your children not undermining one another?
3. How can you compare PMP style of teaching with the way we have been taught?
4. What problems did you as a mathematics teacher encounter in PMP?
5. What advice can you give to the other teachers and officials?

(c): QUESTIONS FOR INSPECTORS AND DIRECTORS:

1. What can you say about the methods of teaching in the project schools.
2. Can you comment about the traditional methods of teaching and the method used in the project schools.
3. We have a problem of overcrowded classes, how can we overcome this problem?
4. What do you want to see happening in a mathematics classroom environment?
5. How do you rate today's parents with regard to education of their children?

(d): FOR PARENTS:

1. Do you check your child's books?
2. How often do you do that?
3. Have you got a knowledge of mathematics such that you can help your child when s/he request assistance?
4. Do you think your child likes to read books?
5. Does your child ever ask you to assist him/her with home works?

APPENDIX 4.6.1 E: PUPILS' QUESTIONNAIRE

PUPILS' QUESTIONNAIRE

SCHOOL:..... ..... GRADE:.....

BOY / GIRL. AGE:.....years.

INSTRUCTIONS:
In answering an item please indicate; Yes, No or Do not know / Not sure.

i.e. 1 - Yes.
2 - Not sure / Do not know.
3 - No.

Example: One add two equals three.	1	2	3
1. I love mathematics.	1	2	3
2. I like to work mathematics alone.	1	2	3
3. I like to work problems with my friend.	1	2	3
4. I like to work problems in groups.	1	2	3
5. Our teacher usually encourages us to talk when doing mathematics.	1	2	3
6. We often use equipment (materials) in mathematics lessons.	1	2	3
7. Word problems (sums) are difficult.	1	2	3
8. I know multiplication and division tables.	1	2	3
9. My mother or father helps me at home with mathematics.	1	2	3

10. Write a sentence on what you feel is mathematics.

.....

.....

.....

.....

.....

.....

THANK YOU VERY MUCH FOR YOUR KINDNESS.
==========.

APPENDIX 4.6.2 WRITTEN TESTS FOR GRADE 2 TO GRADE 4.

SSB (GRADE 2) - MATHEMATICS.

SCHOOL:..... CHILD'S NAME: .....

A: PRACTICE.

2 + 1 =

3 + 2 =

4 - 1 =

B: Now try to work these:

1. 6 + 3 =.....
.....
.....

2. 18 - 6 =.....
.....
.....

3. 9 + 5 =.....
.....
.....

4. 14 - 8 =.....
.....
.....

5. 32 + 17 =.....
.....
.....

6. 57 - 34 =.....
.....
.....

7. There are 4 people in a taxi. The taxi stops. 3 more people get in. How many people in the taxi now?
.....
.....
.....
.....

8. There are 15 oranges in the bag. The boys eat 7 oranges. How many oranges are left out?
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.....
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.....

9. Temba has 35 cents. Kagiso's money is 47 cents. How much money do they have altogether?

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10. Our class has 52 pupils. The girls are 25. How many are boys?.....

.....
.....
.....
.....
.....

==========

THANK YOU.

APPENDIX 4.6.2 WRITTEN TEST; GRADE 3.

STD 1 (GRADE 3) - MATHEMTICS TEST.

SCHOOL: ..... CHILD'S NAME:.....

A: PRACTICE:

6 + 3 =

9 + 5 =

18 - 6 =

B: NOW DO THESE:

1. 14 - 8 = ...
.....
.....
.....

2. 32 + 17 = ...
.....
.....
.....

3. 4 X 5 = ...
.....
.....
.....

4. 57 - 34 = ...
.....
.....
.....

5. 78 + 324 = ...
.....
.....
.....

6. 278 - 56 = ...
.....
.....
.....

7. Mpho has 35 cents. Kgaogelo's money is 47 cents. How much money do they have together?.....
.....
.....
.....
.....

8. Our class has 52 pupils. The girls are 25. How many are the boys?.....
.....
.....
.....
.....

9. I buy 4 bags of oranges. There are 13 oranges in each bag. How many oranges did I get?.....
.....
.....
.....
.....

10. Thandi counted 87 cars in the street. Tshepho counted 93 cars in the car park. Altogether the cars were how many?.....
.....
.....
.....
.....

==========

GOOD LUCK.

APPENDIX 4.6.2 WRITTEN TEST; GRADE 4.

STD 2 (GRADE 4) - MATHEMATICS TEST.

SCHOOL:..... CHILD'S NAME:.....

A: PRACTICE:

6 + 3 =

9 + 5 =

18 - 6 =

B: NOW DO THESE:

1. 32 + 17 = ...
.....
.....
.....

2. 4 X 5 = ...
.....
.....
.....

3. 57 - 34 = ...
.....
.....
.....
.....

4, 27 - 3 = ...
.....
.....
.....

5. 178 + 324 = ...
.....
.....
.....

6. 278 - 156 = ...
.....
.....
.....

7. Mokgadi counted 87 cars in the street. Puleng counted 93 in the car park. How many cars did they count altogether? .....
.....
.....
.....

8. There are 493 pupils at our school. 235 of them are boys. What is the number of girls at the school?

.....
.....
.....
.....

9. My father picks oranges. He filled 8 bags. He puts 24 oranges in each bag. How many oranges did he pick?

.....
.....
.....
.....

10. A taxi can take 15 people. How many taxis will be needed to take 52 people into town?.....

.....
.....
.....
.....
.....

==========

GOOD LUCK. THANKS.

APPENDIX 5.3 H: TEACHERS AND PUPILS QUESTIONNAIRE RESPONSES (TOTALS)

TEACHERS' QUESTIONNAIRE RESPONSES

QUES.NO	DEF.DISAGR	DISAGR	NOT SUR	AGR	DEF AGR	TOT.RESP
1	11	55	43	49	16	174
2	0	8	23	88	55	174
3	3	2	34	79	41	174
TOTAL fA	13	81	100	216	110	522
4	5	16	25	75	53	174
5	3	12	24	76	59	174
6	16	41	56	38	23	174
7	5	9	18	84	58	174
8	17	16	46	76	19	174
TOTAL fB	41	78	144	274	159	696
9	2	6	5	83	78	174
10	0	7	17	70	80	174
11	3	9	15	81	66	174
12	2	14	14	76	68	174
TOTAL fC	7	36	51	310	292	696
13	1	12	18	58	85	174
14	0	10	21	87	56	174
15	1	10	4	91	68	174
16	3	25	35	58	53	174
TOTAL fD	5	57	78	294	262	696
GRAND TOTAL:	71	268	398	1169	878	2784

NB: Question 4 was excluded from the analysis because it does not fit well to factor A.

TABLE:

APPENDIX TOTAL QUESTIONNAIRE RESPONSES.

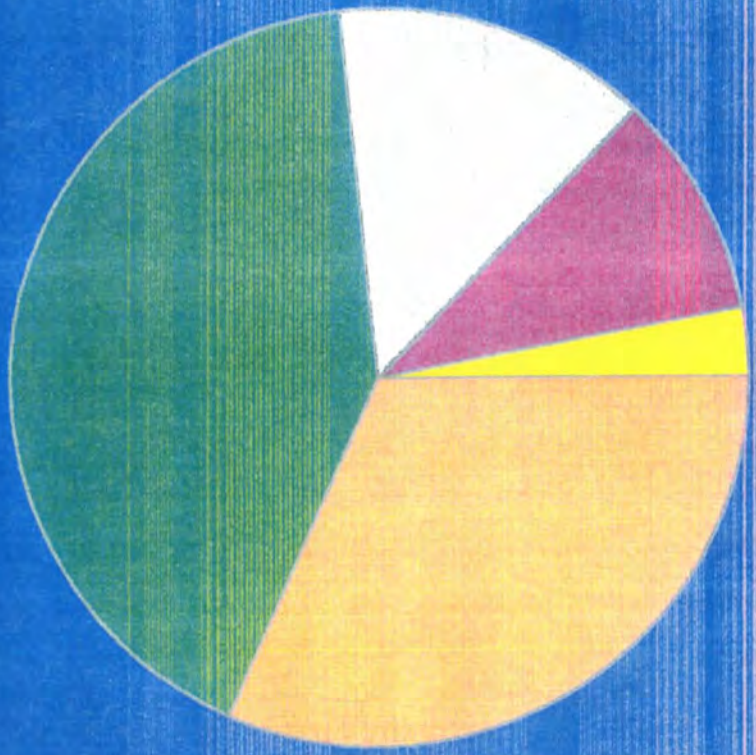
TEACHERS' QUESTIONNAIRE PERCENTAGE (%) OF RESPOSES:

QUEST.NO.	DEF.AGREE	DISAGREE	NOT SURE	AGREE	DEF.AGREE
1	6,3	31,6	24,7	28,2	9,2
2	0	4,6	13,2	50,6	31,6
3	1,1	10,3	19,5	45,5	23,6
TOTAL (fA)	2,5	15,5	19,2	41,4	21,1
4 (TOTAL)	2,9	9,2	14,4	43,1	30,4
5	1,7	6,9	13,8	43,7	33,9
6	9,2	23,6	32,2	21,8	13,2
7	2,9	5,2	10,3	48,3	33,3
8	9,7	9,19	26,43	43,67	10,9
TOTAL (fB)	5,9	11,2	20,78	39,4	22,8
9	1,2	3,4	2,9	47,7	44,8
10	0	4,1	9,8	40,2	45,9
11	1,7	5,2	8,6	46,6	37,9
12	1,1	8,04	8,04	43,7	39,08
TOTAL (fC)	1,0	5,2	7,3	44,5	42,0
13	0,6	6,9	10,3	33,3	48,9
14	0	5,7	12,1	50,0	32,2
15	0,6	5,7	2,3	52,3	39,1
16	1,7	14,4	20,1	33,3	30,5
TOTAL (fD)	0,7	8,18	11,2	42,24	37,6
GRAND TOTAL ALL FACTORS	2,6	9,6	14,3	14,98	31,5

NB: Question 4 was excluded from the analysis because it does not fit well to factor A.

TABLE:

RESPONSES OF TEACHERS' QUESTIONNAIRE



Definitely Disagree Disagree Not Sure Agree Definitely

PUPILS QUESTIONNAIRE RESPONSES:

LOWER PRIMARY (Grade 4):

Question Number	Yes Respons	Not Sure	No	RESPONSES.
1	88,2%	9,9%	1,9%	161
2	70,9%	13,4%	15,7%	172
3	83,1%	8,1%	8,7%	172
4	82,1%	8,7%	9,2%	173
5	85,7%	10,8%	3,5%	175
6	85,3%	8,2%	6,5%	171
7	64,2%	23,9%	11,9%	176
8	66,1%	28,2%	5,7%	174
9	77,0%	2,9%	20,1%	174

HIGHER PRIMARY (Grade 5 -7):

1	78,3%	9,7%	12,0%	300
2	35,1%	8,3%	56,6%	302
3	72,7%	6,5%	20,8%	308
4	73,2%	9,4%	17,4%	310
5	81,8%	7,0%	11,2%	313
6	67,8%	14,4%	17,8%	314
7	30,8%	29,2%	40,0%	305
8	55,5%	36,2%	8,3%	312
9	75,9%	6,3%	17,8%	303

mkqs

APPENDIX 5.3 H: PUPILS' QUESTIONNAIRE RESPONSES.

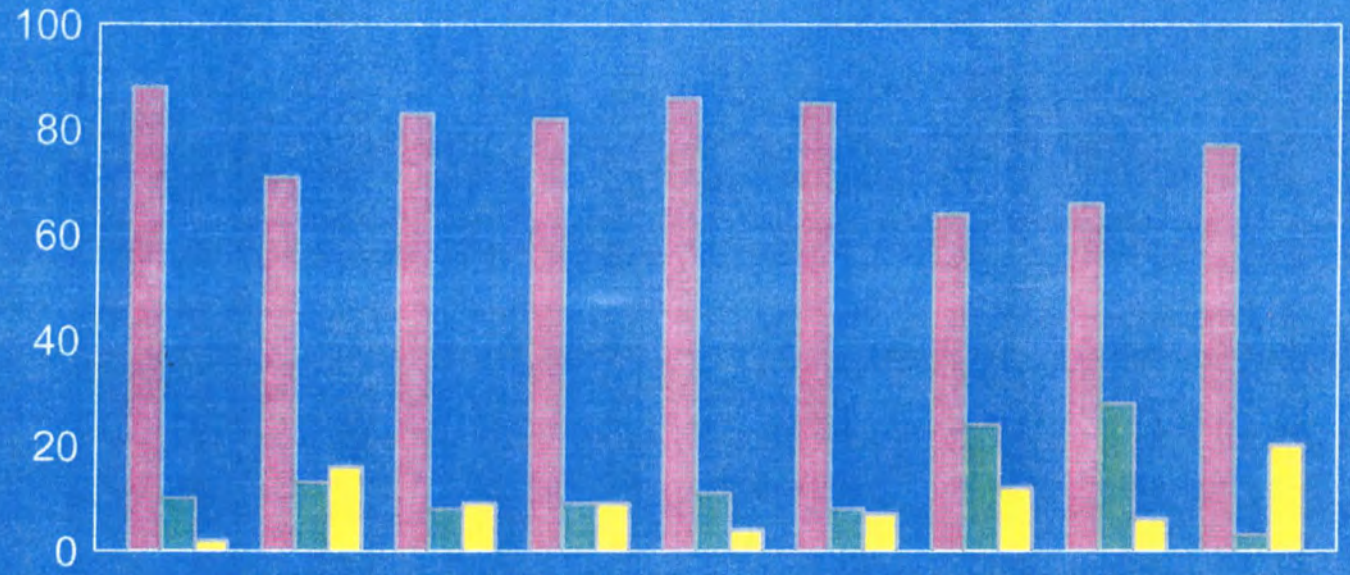
PUPILS' QUESTIONNAIRE RESPONSES

STD 3 - 5:

QUEST. NO.	YES	NOT SURE	NO
1. I love mathematics.	132 79,0%	19 11,4%	16 9,6%
2. I like to work mathematics alone.	74 45,4%	13 7,9%	76 46,6%
3. I like to work problems with my friend.	112 66,7%	11 6,5%	45 26,8%
4. I like to work problems in groups.	113 66,9%	15 8,9%	41 24,3%
5. Our teacher usually encourages us to talk when doing mathematics.	135 78,0%	13 7,5%	25 14,5%
6. We often use equipment (materials) in mathematics lessons.	122 70,5%	16 9,2%	35 20,2%
7. Word problems (sums) are difficult.	65 38,7%	16 9,5%	87 51,8%
8. I know multiplication and division tables.	122 71,3%	33 19,3%	16 9,4%
9. My mother or father helps me at home with mathematics.	112 67,9%	6 3,6%	47 28,5%

mkgs.

RESPONSES OF PUPILS' (Std 2) QUESTIONNAIRE



	Question 1	2	3	4	5	6	7	8	9
Yes Response	88	71	83	82	86	85	64	66	77
Not Sure	10	13	8	9	11	8	24	28	3
No	2	16	9	9	4	7	12	6	20

APPENDIX 5.4.I: WORD PROBLEMS FOR CLASSROOM PRACTICE.

WORD PROBLEMS FORMULATED DURING T.S.P. COURSE IN PIETERSBURG CLUSTER. 27TH-29TH JUNE 1995.

GROUPI.

Gradel (SubA):

1. A hen lays two eggs per day. How many eggs will it lay in a week?
2. There are two birds on the tree, Sipho shoots one. How many are left?
3. I have two baskets and in each basket there are four buns. How many buns are there altogether?

Grade2 (SubB):

1. I have ten shoes,five left and five right. How many pairs are there?
2. I have three triangles.How many corners are there altogether?
3. I have a balloon and my mother gives me three more, two burst. How many balloons am I left with?

Grade3 (STD1):

1. Peter had 95c, he bought a bicycle tube with 30c. How much change did he get?
2. Mary goes to school regularly except on Thursdays. For how many does she go to school in a month?

Grade4 (STD2):

1. 1000ml makes a litre. How many litres are there in 42000ml tank?
2. Tickets to the circus cost R2,00. The total amount of money collected from the tickets sold was R594,00. How many tickets were sold?
3. John had to run 45km, but he ran only 15km. How many more kilometres he still have to run?

==========

GROUP II:

Gradel (SubA):

1. Ten doves are on the telephone line. Another 6 come. Thereafter 2 flew away. How many are left?

Grade2 (SubB):

1. Mother has 5 hens. Each has 2 eyes. What is the total number of eyes for the 5 hens?
2. Father had 20c from his pocket. He buys a match box for 15c. How much change does he has?

Grade3 (Std1):

1. John walks 3km, How far will he walk in 4 hours?

Grade4 (Std2):

1. A farmer has 3 rows of orange trees with 2 trees in each row. How many baskets of oranges can he expect to harvest if each tree produces 4 baskets?
2. A farmer has a total number of 938 livestock on his farm. 389 are cattle and 318 are goats. how many sheep are there on the farm?

Grade6 (Std4):

1. You buy 9 bags of potatoes at R6,50 per bag and sell the potatoes at 25c each. What is your total profit or loss if there are 36 potatoes to a bag?

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GROUP III:

Grade1 (SubA):

1. John has 5 sweets, Mary has 3 sweets and Peter has 2 sweets. What is the total number of the sweets?
2. A girl has 2 eyes. How many eyes do 4 girls have?

Grade2 (SubB):

1. A car has 4 wheels. How many wheels have 3 cars got?
2. Mother has 20 bananas in the bucket. Peter stole 6 bananas. How many bananas is left in the bucket?

Grade3 (Std1):

1. Mother has 24 apples. She has to share them among 8 children. How many apples must each child get?
2. Given bought a bicycle for R20. How much will 3 bicycles cost?

Grade4 (Std2):

1. A car cost R9000. After paying deposit the balance is R3000. What will be the monthly instalment if he has to pay within 5 months?
2. Each child in the class has 36 books. What will be the total number of books for 5 children?

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GROUP IV:

Grade1 (SubA):

1. A hen lays 5 eggs. A dog ate 3 of them. How many eggs are left?

Grade3 (Std1):

1. Our principal has 4 sheep. He sold 2 for R40 each. How much will he get for those 2?

Grade4 (Std2):

1. A boy gets up at 06h15. He arrives at school at 07h20. How long did it take from the time he got up until the time he arrives at school?
2. Mother has 20 cakes. She sells each for R20,00. How much will she get after selling them all?

Grade6 (Std4):

1. Mr Storekeeper bought the following items at Pietersburg Wholesalers:
   4 X 2kg surf at R18,00 each,
   4 X 2kg omo ast R18,00 each,
   2 X 2kg lactogen at R11,80 each. What is the total VAT of the total amount?

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GROUP V:

Grade1 (SubA):

1. Mary has 10 sweets. Her brother gives her another 2 sweets. How many sweets does she have altogether?
2. Samuel has 9 books. He lost 4 books. How many books are left?

Grade1 & 2:

1. You have 20 pencils, on the way, lost 5 and picked up 7 on the way, so how many pencils do you have now?
2. Jane has 3 packets of sweets, each contains 3 sweets. How many sweets are there in all?

Grade3 & 4 (Std1 & 2):

1. A boy bought a ball for R5,95 and a T-shirt for R8,50. They gave him a discount for R2,50. How much will he pay?
2. John has 5 shirts and 3 trousers. They match each other. How many times shall he puts on shirts and trousers?
3. Rosa has 15 apples to share. She has 3 kids. One gets 3 less than the others. She share the remaining equally. How many will each have?

Grade4 (Std2):

1. A man has 30 cattle and 33 sheep. He wants to divide them between three children equally. How many cattle and sheep will each have?

2. Betty serves tea to 10 visitors. Six visitors came in. From the six visitors, two of them do not take tea. How many visitors were served with tea?
3. A paraffin tank is 50 litres. Man sells 10 litres at 50c each and make a total of R5,00. How much will the remaining litres cost at the same price?

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